US  CMS

The Compact Muon Solenoid

US CMS

Project Management Plan

Draft

April 11, 1997

US CMS Project Management Plan

ABSTRACT

This Management Plan sets forth the specific plans, organization, responsibilities and systems to be used in managing the work necessary for successful completion of the US Compact Muon Solenoid (CMS) construction project. The US CMS construction project is both a DOE Major Systems Acquisition (MSA) project and an NSF Major Research Equipment (MRE) project, with the project office located at the Fermi National Accelerator Laboratory. This project includes the construction of elements of the CMS detector for which the US groups collaborating on CMS take responsibility.

The US groups will participate in the building of the Compact Muon Solenoid (CMS) experiment which is designed to study the collisions of protons on protons at a center of mass energy of 14 TeV at the Large Hadron Collider (LHC) at CERN. To enable studies of rare phenomena at the TeV scale, the LHC is designed to operate at a luminosity of 10^{34} cm^{-2} s^{-1}. The physics program includes the study of electroweak symmetry breaking, investigation of the properties of the top quark, searches for new heavy gauge bosons, probing quark and lepton substructure, looking for supersymmetry and exploring for other new phenomena. The CMS collaboration has proposed to build a compact solenoidal detector designed to function at the highest luminosities available at the LHC. The detector will be built around a high-field (4 T) superconducting solenoid, leading to a compact design for the muon spectrometer. In order to detect new physics signatures efficiently identification of muons, photons, electrons, and neutrinos has been emphasized. The US CMS Group agrees to take leadership responsibility in the CMS experiment for the endcap muon system including the chambers, steel design and integration, and for all hadron calorimetry, as well as associated aspects of the trigger and data acquisition system. The US CMS Collaboration also agrees to work on important areas of electromagnetic calorimetry, tracking, and software.

This plan will be kept current as the project progresses. An annual review of the plan, with appropriate updating of sections, will be made to assure that it is current. The US CMS Project Office is keeping the Project Management Plan (PMP) current by page changes. The US CMS PMP will be distributed as a controlled document by the US CMS Project Office at Fermilab. Changes will also be distributed by the US CMS Project Office.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAAP	Advance Acquisition or Assistance Plan
ACWP	Actual Cost of Work Performed
APP	Advance Procurement Plan
BAO	Batavia Area Office
BC	Budgeted Cost
BCCB	Baseline Change Control Board
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
CCB	Configuration Control Board
CD	Construction Directive
CDR	Conceptual Design Report
CERN	European Laboratory for Particle Physics
CH	Chicago Operations Office
CMS	Compact Muon Solenoid
CPR	Cost Performance Report
CSCG	Cost/Schedule Controls Group
CS^2	Cost Schedule Control System
DAQ	Data Acquisition
DCC	Document Control Center
DHEP	Division of High Energy Physics
DOE	Department of Energy
EA	Environmental Assessment
EAC	Estimate at Completion
ECAL	Electromagnetic Calorimeter
ECR	Engineering Change Request
EMU	Endcap Muon System
ER	Office of Energy Research
ESAAB	Energy System Acquisition Advisory Board
ES&H	Environment, Safety and Health
FES	Facilities Engineering Services
FIFS	Fermilab Integrated Financial System
FNAL	Fermi National Accelerator Laboratory (Fermilab)
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report
GeV	Giga-electron-Volt
HCAL	Hadron Calorimeter
HENP	High Energy and Nuclear Physics
L2M	Level 2 Manger
MAP	Mitigation Action Plan
MOU	Memorandum of Understanding
MRE	Major Research Equipment
MSA	Major System Acquisition
NSF	National Science Foundation

PMG	Project Management Group
PMP	Project Management Plan
PSAR	Preliminary Safety Analysis Report
PSWBS	Project Summary Work Breakdown Structure
QA	Quality Assurance
QAC	Quality Assurance Committee
QAP	Quality Assurance Plan
QC	Quality Control
R&D	Research and Development
SOW	Statement of Work
SQIP	Specific Quality Implementation Plan
TEC	Total Estimated Cost
TeV	Tera-electron-Volt
TPC	Total Project Cost
URA	Universities Research Association
WBS	Work Breakdown Structure

Section I
Introduction

I. Introduction

This document describes the Project Management Plan (PMP) that the US CMS Collaboration will follow to meet the technical, cost, and schedule objectives of the US CMS Project, a Department of Energy (DOE) Major System Acquisition (MSA) and NSF Major Research Equipment (MRE) Project. The project will have its management office at Fermilab, in Batavia, Illinois. Fermilab is a DOE Laboratory operated under contract DE-AC02-76-CH-03000 by the Universities Research Association, Inc. (URA). DOE, NSF, Fermilab and the US CMS Collaboration will work together as a team to accomplish the US CMS Project. This PMP for construction of US CMS, a project baseline and execution document, sets forth the plans, organization and systems that will be used to manage this DOE MSA and NSF MRE project.

A. The US CMS Project

The US CMS Collaboration is part of CMS. CMS is a collaboration which will conduct an experimental investigation of the interactions of protons on protons at a center of mass energy of 14 TeV at the Compact Muon Solenoid (CMS) experiment planned for the Large Hadron Collider (LHC) at CERN. In order to explore the TeV mass scale, the LHC is designed to operate at a luminosity of 10^{34} cm^{-2} s^{-1}. The physics program includes the study of electroweak symmetry breaking, investigation of the properties of the top quark, searches for new heavy gauge bosons, probing quark and lepton substructure, looking for supersymmetry and searching for other phenomena outside the standard model. Models of electroweak symmetry breaking generally include a scalar field whose interactions give mass to the W and Z bosons, as well as the fermions. The dynamical component of this scalar field, the Higgs boson, is expected to decay into WW and ZZ pairs if its mass exceeds 180 GeV. Other theories predict new particle states that decay to ZZ, WW, WZ or Z pairs. Thus, the study of boson pairs is an important venue for understanding electroweak symmetry breaking. This study requires efficient detection of the W and Z decay electrons, neutrinos and muons over as large a solid angle as possible.

The CMS detector is designed to exploit the full range of physics at the LHC up to the highest luminosities. The detector tracking and calorimetry components are to be built within a high-field (4 T) superconducting solenoid, leading to a compact design for the muon spectrometer. Identification of muons, photons and electrons, and precise measurement of these particles with an energy resolution of 1% over a large momentum range, are emphasized in the design considerations. A perspective view of the CMS Detector is shown in Fig. I-1.

There are two systems where the US has overall responsibility: the endcap muon (EMU) system and the hadron calorimeter (HCAL) system. US CMS groups

will take construction responsibility for these and other items. The US has complete endcap management responsibility, but only partial construction responsibility. Three of the four detector stations will be built by the US. The US will design the endcap steel; it will be constructed as a CMS common project. The hadron calorimetry is similarly partitioned: the US groups will build the barrel, supply the endcap transducers and front-end electronics, and build half of the forward system while maintaining complete HCAL management responsibility. In addition, as the HCAL is supported off the solenoid cryostat, US groups are involved in the design of the cryostat and will construct elements of it as a CMS Common Project.

For the other subsystems, the US responsibilities are not global. However, in every case they are focused on particular area of US expertise. For example, US groups have overall CMS trigger management responsibility and will do essentially all endcap muon level 1 triggers and all calorimeter level 1 triggers, and all endcap silicon pixels.

B. The Participants

The major participants in the US CMS Project are: the DOE Office of Energy Research (ER); the National Science Foundation Division of Physics; Fermilab, operated by URA, as host Laboratory; and the collaborating US CMS institutions. In addition, the CMS detector will be operated at CERN near Geneva, Switzerland. The CMS experiment is an international enterprise of which the US CMS Collaboration is only a part.

A substantial number (~330) of US physicists and engineers have been welcomed as full partners in the CMS collaboration. A list of the current institutions and contact persons of US CMS is given in Table I-1.

The areas of construction responsibility of the US CMS institutions are given in Table I-2.

C. The Project Management Plan

The PMP presents the top level technical, cost, and schedule baselines for the US CMS Project, and sets forth the organization, systems, and plan by which the project participants will manage the US CMS Project.

The management approach described here is based on ER and NSF experience with projects to construct complex detectors designed as research tools to advance the frontiers of knowledge. Three fundamental principles underlie the development of an organizational structure, the assignment of roles and responsibilities, and the implementation of management systems to optimize the success of such projects. These principles are as follows:

a. The US CMS Project Manager/Spokesperson is nominated by the US CMS Collaboration, and is jointly appointed by DOE, NSF, and Fermilab. The US CMS PM/Spokesperson has the technical responsibility for the successful achievement of the performance goals within the cost and schedule objective.

b. Relevant formal management systems and requirements are implemented consistent with optimizing the project success and accounting properly for the use of public funds. Fermilab has management oversight responsibility for the US CMS Project. To achieve the oversight goal, Fermilab will convene a project Management Group which will report to DOE and NSF and which will act as the change control board for the US CMS Project.

c. Project Management is a team approach involving DOE ER, NSF, Fermilab, and US CMS.

Following this introductory section, Section II provides an overview of the US CMS Project, the design goals, scope and objectives. The roles and responsibilities of the major project participants are defined in Section III. Section IV through VII describe the work and its organization and the associated cost, schedule, and technical baselines. A discussion of the system that will be used to manage and control cost and schedule and to measure the technical performance of the project is given in Section VIII. Reporting requirements and review procedures are described in Section IX.

This plan will be reviewed and revised, as required, to reflect new project developments and/or other agreements among the participants. Revisions, as they are issued, will be signed by all participants, and will supersede in their entirety previous editions. To the extent that there are inconsistencies or conflicts between this plan and the terms and conditions of applicable laws, regulations, and contracts, the provisions of those documents shall prevail over this plan.

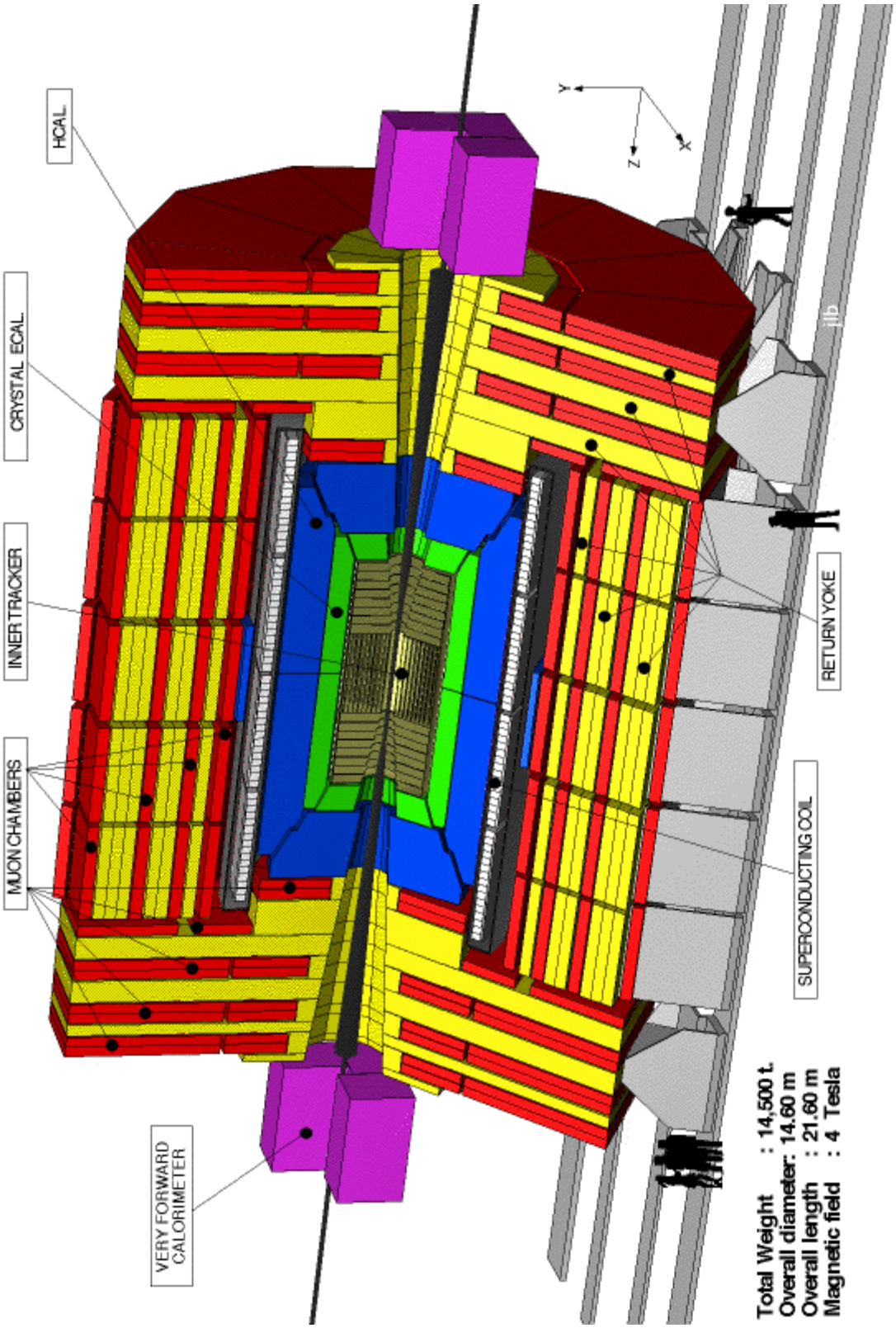

Fig. I-1: View of the CMS Detector.

Table I-1: US CMS Collaboration.

US CMS Collaboration

Collaboration Board Chair: D. Reeder Project Manager/Spokesperson: D. Green

Institution	Contact Person
University of Alabama	L. Baksay
Boston University	L. Sulak
Brookhaven National Laboratory	C. Woody
University of California, Davis	W. Ko
University of California, Los Angeles	K. Arisaka
University of California, Riverside	J. G. Layter
University of California, San Diego	J. G. Branson
California Institute of Technology	H. Newman
Carnegie Mellon University	T. Ferguson
Fairfield University	D. Winn
Fermi National Accelerator Laboratory	D. Green
University of Florida	G. Mitselmakher
Florida State University	V. Hagopian
Florida State University (SCRI)	M. Corden
University of Illinois at Chicago	M. Adams
University of Iowa	Y. Onel
Iowa State University	E. W. Anderson
Johns Hopkins University	C. Y. Chien
Lawrence Livermore National Laboratory	C. Wuest
Los Alamos National Laboratory	H. J. Ziock
University of Maryland	A. Skuja
Massachusetts Institute of Technology	P. Sphicas
University of Minnesota	R. Rusack
University of Mississippi	J. Reidy
University of Nebraska	G. R. Snow
State University of New York at Stony Brook	M. Baarmand
Northeastern University	S. Reucroft
Northwestern University	B. Gobbi
University of Notre Dame	R. Ruchti
Ohio State University	T. Y. Ling
Princeton University	P. Piroue
Purdue University	V. E. Barnes
Rice University	D. L. Adams
University of Rochester	A. Bodek
University of Texas at Dallas	E. J. Fenyves
Texas Tech University	R. Wigmans
Virginia Polytechnic Institute and State University	L. W. Mo
University of Wisconsin	W. H. Smith

Table I-2: US CMS Subsystem Participation.

Endcap Muon	Hadron Calorimeter	Trigger/DAQ
Alabama	Boston	UC Davis
UC Davis	UCLA	UCLA
UCLA	Fairfield	UC San Diego
UC Riverside	Fermilab	Fermilab
Carnegie Mellon	Florida State	Iowa
Fermilab	Illinois Chicago	Iowa State
Florida	Iowa	MIT
Livermore	Iowa State	Mississippi
SUNY Stony Brook	Maryland	Nebraska
Northeastern	Minnesota	Northeastern
Ohio State	Mississippi	Ohio State
Purdue	Notre Dame	Rice
Rice	Purdue	Wisconsin
UT Dallas	Rochester	
Wisconsin	Texas Tech	
	Virginia Tech	

Electromagnetic Calorimeter	Tracking	Software
Brookhaven	UC Davis	UC Davis
Caltech	Fermilab	UCLA
Fermilab	Florida State (SCRI)	UC Riverside
Livermore	Johns Hopkins	UC San Diego
Minnesota	Livermore	Caltech
Northeastern	Los Alamos	Carnegie Mellon
Princeton	Mississippi	Fermilab
	Northwestern	Florida
	Purdue	Florida State (SCRI)
	Rice	Johns Hopkins
	Texas Tech	Livermore
		Maryland
		Missesota
		SUNY Stony Brook
		Northeastern
		Princeton
		Purdue
		Rice
		Wisconsin

Section II
Project Objectives

II. Project Objectives

A. Project Purpose

The purpose of the US CMS Project is to enable US high energy physicists to participate in research at the high energy frontier available at the Large Hadron Collider (LHC) at CERN.

The US CMS project is described in the US CMS Letter of Intent of September 8, 1985 and in the US CMS Project Status Report of October 15,1996, and is outlined below. US responsibilities within CMS include both management and construction.

US groups have management responsibility for the endcap muon system, the hadron calorimeter, and the trigger. Construction responsibilities within the US extend to portions of all five CMS subsystems: Muon, Hadron Calorimeter, Trigger/DAQ, Electromagnetic Calorimeter, and Tracking. In addition, there is US participation in both the Common Projects and the costs of the Project Office at Fermilab are explicitly called out. Hence, there are seven WBS level 2 categories, as discussed in Section V.

Detection of muons is of central importance in the CMS experiment since muons from p-p collisions will provide clean signatures for a wide variety of new physics processes. The task of the muon detector is to identify these muons and provide a precision measurement of their momenta which ranges from a few GeV to a few TeV. At the LHC, efficient detection of muons from Higgs, W and Z sources requires coverage over a large rapidity interval. The CMS muon system design includes a barrel detector, which has standalone coverage for $0.0 < |\eta| < 0.9$, and an endcap detector, which overlaps the barrel in the region $0.9 < |\eta| < 1.3$ and provides standalone coverage for $1.3 < |\eta| < 2.4$. The endcap detector is crucial for the identification of these processes. For example, simulation studies of the distribution of the most forward muon in Higgs decays show that at least one muon typically appears in the endcap region. US CMS responsibilities are for construction of the endcap muon chambers and level 1 trigger and for design of the steel return yoke.

The basic functions of the CMS calorimeter systems are to identify electrons and photons and to measure their energies (in conjunction with the tracking system), to measure the energies and directions of particle jets, and to provide hermetic coverage for measuring missing transverse energy. The central pseudorapidity range ($|\eta| < 3.0$) is covered by the barrel and endcap calorimeter system (HB, HE, EB, and EE), while the forward region ($3.0 < |\eta| < 5.0$) is covered by the forward calorimeter system (HF). The barrel and endcap calorimeters sit inside the 4 Tesla field of the CMS solenoid and hence are necessarily fashioned out of non-magnetic material (copper and stainless steel). The barrel hadron calorimeter

inside the solenoid is relatively thin. To ensure adequate sampling depth a hadron shower "tail catcher" is installed outside the solenoid coil in both the barrel and endcap regions. The active element of the central hadron calorimeter readout consists of 4 mm thick plastic scintillator tiles with wavelength-shifting (WLS) fiber readout. US CMS responsibilities are for construction of the entire barrel, the endcap transducers and readout, and roughly half of the forward system.

US physicists also have responsibilities within the CMS trigger and data acquisition system. For the nominal LHC design luminosity of 10^{34} cm^{-2} s^{-1}, an average of 25 events occur in each crossing with a beam crossing frequency of 25 nsec. This input rate of 10^9 interactions every second must be reduced by a factor of at least 10^7 to 100 Hz, the maximum rate that can be archived by the on-line computer farm. CMS has chosen to reduce this rate in two steps. The first level stores all data for 3 μsec, after which no more than a 100 kHz rate of the stored events is forwarded to the higher level triggers. This must be done for all channels without dead time. The second level trigger is provided by a subset of the on-line processor farm, and passes a fraction of these events for more complete processing by the remainder of the on-line farm. During the 3 μsec of level 1 trigger, decisions must be developed that discard a large fraction of the data while retaining the small portion coming from interactions of interest. The large physical size of the detector and the short decision time present a series of technical and system problems. In as much as the design of an LHC detector trigger system strongly impacts the design of the detector, an LHC detector cannot be designed without addressing the trigger design. US CMS responsibilities are for construction of the level 1 calorimeter and endcap muon trigger and elements of the level 2 event builder switch.

The CMS electromagnetic calorimeter (ECAL) will be a lead tungstate crystal calorimeter. This is a complete absorption calorimeter, with uniform hermetic coverage, capable of achieving the energy resolution required to detect an intermediate mass Higgs decaying into two photons. Lead tungstate crystals have a short radiation length (0.89 cm) and a small Molière radius (2.0). They have a low light yield but this problem is effectively overcome by using large area silicon avalanche photodiodes (APDs). Recently, crystals supplied by the Shanghai Institute of Ceramics have shown no change in light output or attenuation length after 50 kGy (5 Mrads) of ^{60}Co irradiation. US CMS responsibilities in ECAL are to provide a fraction of the transducers, front end electronics, and monitoring systems.

A pixel vertex detector with two barrel layers plus three pixel disks at each end has been adopted as part of the baseline design set out in the CMS Technical Proposal. The US will provide all the forward pixel disks. The goal of the forward pixel disks is to extend precision tracking and secondary vertex measurements out to η of order 2.6 (consistent with the rest of the forward detector) with at least two measurements on a track. The Technical Proposal design has three disks per endcap (actually rings with 7.5 cm inner radius and 15 cm outer radius). The pixels are rectangular (50 x 300 μm^2) with the long dimension approximately radial.

B. Technical Objectives

[To be completed when the Memorandum of Understanding with CERN is complete; and following the baseline review of US CMS by DOE and NSF.]

C. Schedule Decision Points[1]

The key decision points and other milestones for the project are shown in Fig. II-1. This overall CMS schedule defines the US CMS Project schedule in as much as the US group are responsible for a subset of the experimental apparatus. Greater schedule details are shown in Section VI. A US CMS level 1 schedule is derived from, and is consistent with, the overall CMS planning. The level 2 managers then create a level 2 schedule which is tied to the level 1 milestones.

D. Cost Objectives

The Total Estimated Cost (TEC) for construction of the US CMS Project is $148,315,000 in FY'96 dollars. The cost estimate is summarized in Table II-1. Detailed discussion of the cost estimates, together with obligations and cost profiles based on schedules described in Section VI, are presented in Section VII.

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[1]Both the schedule and cost are, of course, dependent on the rate of funding. The schedule dates represent the results of discussions between CERN, CMS, DOE/NSF and US CMS.

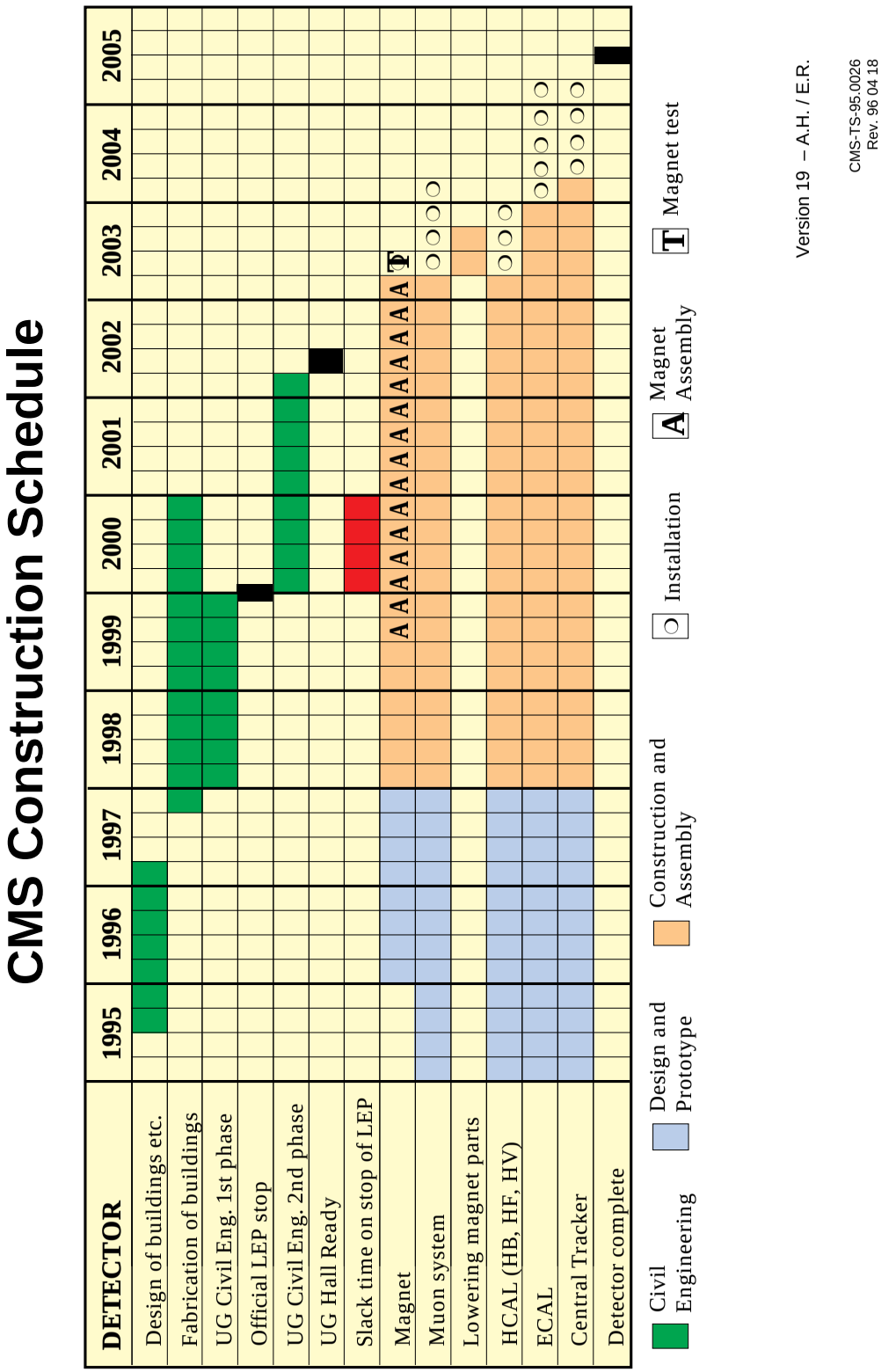

Fig. II-1: CMS Construction Schedule.

US CMS Project Cost Estimate

draft: 20 Mar 97

WBS Number	Description	US Mfg M&S (K$)	US Mfg Labor (K$)	US EDIA (K$)	US Base Cost (K$)	US Cont (K$)	US Cont (%)	Total US Cost (K$)	DOE Request (K$)	NSF Request (K$)
US CMS Total Project Cost (then-yr $s)								**173,971**	**149,468**	**24,502**
Escalation								25,656	21,936	3,720
FY'96 R&D								2,500	2,300	200
US CMS Total estimated Cost (FY'96 $s)								**145,815**	**125,233**	**20,582**
Total Subsystem Estimated Cost (FY'96 $s)		**58,347**	**12,096**	**19,208**	**89,651**	**26,656**	**29.7**	**116,307**	**99,628**	**16,679**
1	**Endcap Muon System**	**16,684**	**6,051**	**5,733**	**28,468**	**7,796**	**27.4**	**36,264**	**34,600**	**1,664**
1.1	Muon Measurement System	16,684	6,051	5,733	28,468	7,796	27.4	36,264	34,600	1,664
2	**Hadron Calorimeter**	**24,260**	**3,066**	**5,747**	**33,073**	**10,450**	**31.6**	**43,523**	**36,477**	**7,046**
2.1	Barrel Hadron Calorimeter	18,618	2,210	4,550	25,377	7,962	31.4	33,340	30,052	3,288
2.2	Endcap Hadron Calorimeter	3,285	530	650	4,465	1,519	34.0	5,984	2,225	3,759
2.3	Forward Calorimeter	2,358	326	547	3,231	969	30.0	4,200	4,200	0
3	**Trigger/Data Acquisition**	**9,957**	**464**	**3,892**	**14,313**	**4,112**	**28.7**	**18,425**	**16,567**	**1,858**
3.1	Endcap Muon Level 1 CSC Trigger	1,208	0	893	2,102	609	29.0	2,711	2,711	0
3.2	Calorimeter Level 1 Regional Trigger	3,089	0	1,499	4,588	1,330	29.0	5,918	5,918	0
3.3	Luminosity Monitor	345	42	48	435	87	20.0	522	0	522
3.4	Data Acquisition	5,315	422	1,452	7,189	2,085	29.0	9,274	7,937	1,336
4	**Electromagnetic Calorimeter**	**5,159**	**1,352**	**1,913**	**8,424**	**2,148**	**25.5**	**10,573**	**7,832**	**2,741**
4.1	Barrel Photodetectors	2,067	317	484	2,868	763	26.6	3,631	890	2,741
4.2	Barrel Electronics	2,409	440	920	3,769	1,128	29.9	4,897	4,897	0
4.3	Special Engineering	166	269	358	793	77	9.7	870	870	0
4.4	Monitor Light Source	487	321	106	914	168	18.4	1,082	1,082	0
4.5	Crystal R&D	30	5	45	80	12	15.0	92	92	0
5	**Tracking**	**2,287**	**1,163**	**1,922**	**5,373**	**2,149**	**40.0**	**7,522**	**4,153**	**3,369**
5.1	Forward Pixel Tracker	2,287	1,163	1,922	5,373	2,149	40.0	7,522	4,153	3,369
6	**Common Projects**	**23,013**	**0**	**0**	**23,013**	**0**	**0.0**	**23,013**	**19,712**	**3,301**
7	**Project Management**	**0**	**0**	**5,134**	**5,134**	**1,361**	**26.5**	**6,495**	**5,892**	**602**
7.1	Project Administration	0	0	2,968	2,968	710	23.9	3,678	3,076	602
7.2	Technical Coordination	0	0	2,166	2,166	651	30.0	2,817	2,817	0

Table II-1: US CMS Project Cost Estimate.

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Section III

Project Organization and Responsibilities

III. Project Organization and Responsibilities

A. Introduction

The US CMS Project operates within the context of CMS as an internationally funded experiment located at CERN. The CERN management has ultimate responsibilities for CMS and requires that CMS report to it. The executive function in CMS is provided by the CMS Management Board. The composition of that board is given in Fig. III-1. The CMS Management Board is advised on technical matters by the Technical Board (Fig. III-2) and on financial matters by the Finance Board (Fig. III-3).

Within CMS, the US CMS Collaboration acts congruently with a governance which is described below. Nevertheless, as a US Project, US CMS is financially responsible ultimately to DOE and NSF.

B. US CMS Organization

The organization of the US CMS Collaboration is described below. The organization of the full CMS Collaboration is described in the CMS Constitution of September 13, 1996.

1. Membership

All US members of the CMS Collaboration are members of the US CMS Collaboration. Institutions which have applied for CMS membership but have not yet been accepted or rejected shall be non-voting members of the US CMS Collaboration. (The US CMS institutions and members are listed in Table IX-1.)

2. Collaboration Board

The US CMS Collaboration Board is the governing body and highest authority of the US CMS Collaboration. The Collaboration Board is composed of one representative from each US institution that is a member of the CMS Collaboration. An Institutional Representative is chosen by each US CMS institution. The chair of the Collaboration Board is elected by the board, and serves as the US representative on the CMS Management Board. Collaboration Board decisions are reached by consensus whenever possible. In the event a consensus cannot be reached, matters are decided by a majority vote of the members. (The US CMS Collaboration Board members are indicated in the listing in Table IX-1.)

Meetings

The US CMS Collaboration Board shall hold at least one meeting per year. Presently, the annual meeting and election of officers is held in the spring (April), and a second meeting is held in the fall before the annual budget submission. Other

meetings may be called as necessary by the Collaboration Board Chair, or by 25% of the Collaboration Board members. Collaboration Board meetings will be open to all US CMS members, but only the Institution Representative or designee may vote.

Minutes of all US CMS Collaboration Board meetings shall be provided by the US CMS Collaboration Board Chair. The minutes shall be submitted for approval at the next subsequent Collaboration Board meeting, and shall be publicly available to all US CMS Collaboration members.

Voting

Each US CMS Institution shall have one vote, to be cast by the Institutional Representative or designee. The Institutional Representative may designate another CMS member from the same institution as that institution's voting representative.

Elections

Nominations for US CMS elective offices may be made by any US CMS member, and must be seconded by a member of the Collaboration Board. The US CMS Project Manager/Spokesperson shall supervise the election of the US CMS Collaboration Board Chair and of members of the US CMS Management Board. The US CMS Collaboration Board Chair shall supervise the recommendation of the US CMS Project Manager/Spokesperson to DOE and NSF and Fermilab for appointment by them. Elections shall be conducted by secret ballot, with the majority of votes of all US CMS institutions being required for election. In the event no candidate receives a majority vote on the first ballot, a runoff between the two candidates receiving the largest number of votes shall be conducted.

Elective Offices

The US CMS elective offices are the US CMS Collaboration Board Chair and the chairs of the respective institution boards of the EMU, HCAL, TRIDAS, ECAL, Tracking, Physics, Software, and Education. The IB for Physics and Education is, by definition, the full CB. The term of these offices shall be two years, with the possibility of renewal. In the event of a vacancy in an elective office, a special election to fill the unexpired term shall be conducted.

Appointed Offices

The US CMS appointed offices begin with the Project Manager/Spokesperson (PM). The nominee is provided by US CMS and recommended to DOE, NSF and Fermilab. The PM is subsequently appointed by DOE, NSF and Fermilab. In turn, the PM appoints Level 2 managers for the WBS categories of EMU, HCAL, TRIDAS, ECAL, Tracking, Common Projects, and Project Office.

Competence

Should serious problems arise concerning the performance of any member of the US CMS Management Board, the recommendation for change shall be brought by the US CMS Collaboration Board Chair. A recommendation for change of the Collaboration Board Chair would be brought by the US CMS PM. A recommendation for change will require a 2/3 majority of the members of the US CMS Collaboration Board. Appointees can only be removed by the PM, in the case of L2 managers, and DOE, NSF, or Fermilab in the case of the PM.

3. Management Board

The US CMS Management Board is the body concerned with directing the US CMS Project. All major decisions of the US CMS Management Board will be submitted to the US CMS Collaboration Board for ratification. The Management Board is composed of the US CMS PM/Spokesperson, of the US CMS Collaboration Board Chair, of US CMS L2 managers, of an elected representative from Physics, Education, Software, EMU, HCAL, TRIDAS, ECAL and Tracking institution boards, of liaisons to the US funding agencies and of the technical managers of the major US subsystems. The organization and present members of the US CMS Management Board are shown in Fig. III-4.

Minutes of all US CMS Management Board meetings shall be provided by the US CMS PM/Spokesperson. The minutes shall be submitted for approval at the next subsequent Management Board meeting, and shall be publicly available to all US CMS Collaboration members.

Project Manager/Spokesperson

The US CMS PM/Spokesperson is appointed by DOE, NSF, and Fermilab and is the chair of the Management Board. The Spokesperson, acting with the advice and consent of the Management Board, is responsible to his appointees for the management of the US CMS Project. Recommendation of a candidate for the post of PM/Spokesperson comes from the US CMS CB.

CMS Management Representatives

US members of the CMS Management Board may also be members of the US CMS Management Board. CMS Management Board members currently include the US CMS Collaboration Board Chair and Project Managers for the Endcap Muon, Hadron Calorimeter, and Trigger/DAQ subsystems. The organization and present members of the CMS Management Board are shown in Fig. III-1. Wherever possible the CMS governance and the US CMS governance will be made consistent, however, the ultimate choice is left to the US Project Manager in US CMS Project matters.

Appointed L2 Managers

The L2 managers are appointed by the PM, upon the recommendation of the relevant subsystem IB. The L2 managers correspond to the L2 categories in the cost estimate; EMU, HCAL, TRIDAS, ECAL, Tracking, Common Projects and Project Office. In the case of Common Projects and Project Office there is no IB, and the L2 manager is directly appointed by the PM.

US Subsystem Representatives

Each of the eight US Institutional Boards (Physics, Education, Endcap Muon, Hadron Calorimeter, Trigger/Data Acquisition, Electromagnetic Calorimeter, Tracking, and Software) shall biannually elect a representative to the US CMS Management Board. The Institution Board is to be composed of one representative from each US CMS institution that is participating in the corresponding area. Board. The elections will be organized by the PM/Spokesperson acting as Chair of the Management Board, and will require the majority of the votes cast by the subsystem Institution Board for election. In the event no candidate receives a majority of the votes cast on the first ballot, a runoff between the two candidates receiving the largest number of votes shall be conducted. In the event of a tie, the deciding vote shall be cast by the US CMS Collaboration Board Chair (unless the Collaboration Board Chair is a member of that subsystem Institution Board, in which case the US CMS Spokesperson shall cast the deciding vote. US CMS subsystem institutional participation is shown in Table I-2.

Technical Representatives

The US technical coordinators of the major US subsystems who are members of the CMS Technical Board shall be non-voting members of the US CMS Management Board. These technical representatives will provide the technical expertise needed to make informed project decisions. The organization and present members of the CMS Technical Board are shown in Fig. III-2.

Funding Agency Liaisons

The US members of the CMS Finance Board who are liaisons to the US funding agencies (DOE and NSF) shall be members of the US CMS Management Board. The organization and present members of the CMS Finance Board are shown in Fig. III-3.

Project Management Representatives

As it is charged with management oversight, Fermilab will be the location of the project office. The organization of the US CMS Project Office is shown in Fig. III-5. A Project Administrator and a Cost/Schedule Coordinator are appointed by the US CMS Spokesperson, with the advice and consent of the US CMS Management Board, and with the approval of the US CMS Collaboration Board. The US CMS

Project Administrator and the Cost/Schedule Coordinator shall be non-voting members of the US CMS Management Board.

B' Project Management Group

The Department of Energy and the National Science Foundation request that Fermilab exercise management oversight for the US CMS detector project. A Project Management Group (PMG), which will report directly to the DOE and NSF, will be convened by Fermilab for this purpose. It is expected that the PMG will include members from Fermilab, DOE, and NSF. The PMG will also serve as the change control board, an entity whose composition had been left unspecified in the US CMS Project Management Plan (see Project Management Plan Section VIII). The Fermilab Director would then concur in the MOU between CERN and US CMS and in the MOU between US CMS and the collaborating institutions. The responsibilities of Fermilab are spelled out in a letter of joint appointment from DOE and NSF to the Fermilab Director. The PMG is reported to by the US CMS Project Manager. In turn, it independently reports to the JOC.

B''. Joint Oversight Committee

The crucial partnership between the DOE and the NSF and their relations with the US CMS Project Office and the Fermilab Directorate will be handled by a Joint Oversight Committee (JOC) consisting of the Head of Physics at the NSF and the Head of High Energy Physics at the DOE and their designees. Since the two agencies are in partnership for US CMS, such a committee is mandatory. The US CMS Project Manager reports directly to the Joint Oversight Committee and to Fermilab. In addition, a key responsibility of the Project Manager is to provide the budget request and recommended allocation of the assigned budget to the JOC.

C. DOE and NSF Organization and Responsibilities

The Department of Energy and the National Science Foundation have established the need for the US CMS Project by considering and responding to advice from their advisory panel, and in negotiations with CERN. The Department of Energy and the National Science Foundation provide the majority of funding for the US CMS Project . The DOE Division of High Energy Physics and the NSF Physics Division provide annual program guidance to US CMS and to the host laboratory as well as annual guidance on the funding profile for the project. The Department exercises oversight of the project by:

- conducting semi-annual reviews of the project;
- participating in regularly scheduled Project Management Group (PMG) meetings;
- overseeing operations and fabrication activities;
- monitoring project progress via quarterly progress reports; and
- monitoring milestones/performance measures.

D. Fermilab Director

The Fermilab Director has the overall responsibility to the Department of Energy and the National Science Foundation for the management oversight of the US CMS Project. The US CMS Collaboration consults with the Director as part of its procedure for appointing the US CMS PM/Spokesperson. The Project Management Plan, the cost estimate, the schedule, the financial plan for the project, and any out-of-scope changes in the project require the approval of the Director as well as DOE and NSF.

E. Fermilab Deputy Director

The Fermilab Director has delegated certain responsibilities and authorities to the Deputy Director. The Deputy Director is responsible for management oversight of the project. The PM reports to the Deputy Director. The Deputy Director chairs the Project Management Group (PMG) which meets as required to monitor the progress of the project. Oversight of the project is implemented in part through reviews. Along with routine interactions with project management these reviews will identify actions and initiatives to be undertaken to achieve the goals of the project including the allocation of both financial and human resources. The Project Management Group will also function as the Baseline Change Control Board for the project.

To implement the work plan for the project, Memoranda of Understanding (MOU) are written assigning responsibilities and describing the work to be executed. The Deputy Director will concur in all Memoranda of Understanding. The Deputy Director advises the Director on his/her approval of the PMP, the cost estimate, the schedule, and the financial plan and concurs with these approvals.

1. Internal Review Committee

Internal Review Committees provide a means for the PM to review technical, cost, and schedule issues for L2 subprojects. These committees may also be charged with reviewing the physics performance of the subsystem or recommending scope changes. Internal Review Committees are appointed as required by the PM. The PM charges them, often in consultation with the PMG. Reports and recommendations from internal review committees are transmitted to the Project Managers and are in general made available to the entire US CMS collaboration.

Internal Review Boards are also a vehicle for communication between the PM and the US CMS Collaboration. In particular, in response to a technical concern raised by members of the collaboration, the US CMS CB Chair may request that an internal review committee be appointed to provide advice regarding the concern.

2. Subproject Technical Committees

There may be technical committees associated with a subsystem and separate from the US CMS internal review boards discussed above. These are appointed by the L2 manager as needed. Members of such technical committees advise the subsystem L2 managers on technical directions, alternatives, and methods of performance. The members of the committee would include scientists responsible for the design and fabrication of the subsystem or of major tasks within it. Other technical experts may also be included. The membership of sub-project technical committees is chosen by the L2 manager. These committees act in an advisory capacity with decision authority in the hands of the L2 manager.

F. US CMS Project Manager

The US CMS Collaboration is responsible for the design, construction, installation, and commissioning of the US CMS Project.

The US CMS PM retains authority over and responsibility for the achievement of the technical, cost, and schedule goals for this project. The US CMS PM/Spokesperson will establish a project organization which has designated responsibility for the technical, cost, schedule, procurement, and construction aspects of the project. The US CMS PM is jointly appointed by DOE and NSF and by Fermilab. The PM reports to both Fermilab and to DOE and NSF. Reporting to Fermilab is largely done by means of the PMG acting as the change control board. Reporting to DOE and NSF concerns the annual budget request for US CMS and the subsequent annual allocation recommendation made by the US CMS PM for funds provided to individual US CMS institutions.

The PM has the responsibility to complete the Cost and Schedule Plan, and the MOU/Work Plans for the project. The scope of the project is that proposed in the technical design report by the US CMS collaboration as well as any out of scope changes approved by the Fermilab PMG, in consultation with CERN and CMS. The Project Manager has the responsibility to complete the US CMS Project on the agreed upon schedule, and within the agreed upon budget and scope.

The PM is responsible for preparing the Project Management Plan (PMP) and for updating it as necessary with the approval of the Deputy Director. The Project Manager may identify the need for project scope changes as they arise. When there is a need for a change having a significant impact on the physics capability of the detector they report to the CMS Management Board and also identify the need to the Director through the PMG. The PM receives technical advice from Internal Review Committees. The PM creates such committees as needed for technical advice and in consultation with the US CMS CB and the CMS MB appoints their members. The procedure for out-of-scope changes to the project is described in Section VIII of this document.

The PM is responsible for organizing presentations at reviews and status reports on the project to respond to the Director and funding agencies.. The PM will

initiate reviews of L2 subprojects to insure that adequate progress is being made and that the subproject is meeting its technical performance, cost, and schedule milestones. The PM may request a review be organized by the CMS MB when questions of the adequate technical or physics performance of a subsystem are raised.

G. US CMS Project Office

1. Fermilab as US CMS Host Institution

Fermilab has agreed to act as host laboratory to the US CMS Project, and will also serve as geographic host to project reviews. The US CMS Project Office will physically reside at Fermilab, and will provide administration for DOE funds. (Administration of NSF funds is provided by the US CMS NSF Office; see below.) Fermilab will also provide Service Accounts for US CMS groups, and travel and purchasing support will be available.

Use of Fermilab facilities and services shall be agreed upon via MOU exactly as with the use of available infrastructure at any US CMS institution. The Spokesperson/Project Manager must report to the Fermilab Director to provide accountability for all services provided to US CMS which are not paid for by US CMS Project funds. The Director may seek advice from the Fermilab Program Advisory Committee. The provided services may include services provided to the Fermilab CMS group or may be services provided to any other US CMS Institution. These items shall be negotiated annually by Fermilab (as host laboratory), by the US CMS Project Manager, and by the collaborating US CMS institution.

2. Management Reserve and Annual Allocation

The Project Manager shall hold a management reserve each fiscal year. That reserve, no more than 30% of the year's allocation, will be committed by the Project Manager during the course of the year based on performance and need of the various groups in the US CMS Collaboration. The reserve will reside at DOE and NSF and will be allocated to individual US CMS institutions in the same manner as the main fiscal year allocation.

The organization of the US CMS Project Office is shown schematically in Fig. III-5. This office is headed by the US CMS Project Manager. The PM/Spokesperson is appointed by DOE, NSF and Fermilab upon the recommendation of the US CMS Collaboration.

The annual budget allocation for the US CMS Project shall be set directly through negotiations between the PM/Spokesperson and the relevant funding

agencies. Allocations of project funds are the purview of the Spokesperson/Project Manager with the advice and consent of the US CMS Management Board and the concurrence of the Fermilab PMG.

All costs of the Project Office (exclusive of physicist salaries) shall be explicitly borne by the US CMS Project and are called out in the US CMS WBS. The costs of Project Management will not be covered by overhead charges at Fermilab, but will be explicitly included in the project cost estimate.

3. US CMS NSF Office

The US CMS NSF Coordinator shall maintain an office responsible for the administration of NSF funds. The NSF Coordinator is selected by the NSF-funded CMS institutions, and serves as the NSF Liaison on the CMS Finance Board. The organization of the NSF Office is included in the Project Office organization chart shown in Fig. III-5.

4. US CMS Education Office

The US CMS Project Manager shall establish and maintain an Education Office within the US CMS Project Office.

5. Allocation and Funding - PMG and MOU

The allocation of funds within the US CMS Project is the responsibility of the US CMS Spokesperson/Project Manager with the advice and consent of the US CMS Management Board and the concurrence of the Fermilab PMG. The recommended allocation is communicated to the US CMS Project Office and then to the US funding agencies, DOE and NSF, as shown in Figure III-7.

The allocation of funds to US CMS institutions is ultimately defined by the Project Manager. Subsequently, funding is provided to those institutions (including Fermilab as a US CMS collaborating institution) and to Fermilab for whatever amount an institution chooses to receive directly from Fermilab). Explicit arrangements are defined in the US CMS MOU and annual SOW, which appear in Appendices A and B.

6. Fermilab US CMS Experimental Group

The Fermilab CMS physicist group shall be distinct from Fermilab as US CMS host institution, with a leader chosen by that group. The Fermilab CMS Group Leader shall negotiate a US CMS MOU annually with the Spokesperson. The Fermilab CMS group shall function as any other US CMS institution. In particular, the use of Fermilab resources covered in the MOU for the Fermilab group shall cover only those services required by the Fermilab CMS group. Services requested by other US CMS institutions will be negotiated by the PM/Spokesperson and

the individual US CMS institution and shall require the concurrence of the Fermilab Director in the annual US CMS MOU Amendment.

8. WBS Level 2 Managers

The WBS level 2 managers report directly to the US CMS Project Manager and have the specific responsibilities listed below:

- Perform control account management at the second level of the WBS consistent with management responsibilities, organization structure, and commonly accepted practices.
- Ensure that the control account and the schedule status are recorded on a timely basis to maintain current period, cumulative-to-date and at-completion records.
- The WBS level 2 managers are the members of the US CMS management board who are responsible for the particular subsystems of the US CMS work breakdown structure.

Within CMS the detector subsystems are organized as distinct projects. The organization charts for the Muon, HCAL, Trigger/DAQ, ECAL and Tracking Projects are shown in Figs. III. 8, 9, 10, 11, and 12 respectively. The organization of the Software and Magnet Technical Boards are shown in Figs. III-13 and III-14 for completeness.

9. Support and Programmatic Organization

The US CMS Project Manager will draw on Fermilab resources as agreed by the Fermilab Director. Procedures consistent with the Laboratory's current accounting, budgeting, human resources, and procurement department policies will be followed and used throughout the Project.

The Project will obtain support to the extent agreed from the Laboratory's indirect support group, including:

- Accounting
- Budget
- Environment, Safety and Health
- Human Resources
- Legal
- Material
- Facilities Management
- Quality Assurance and Value Engineering Office
- Information Services

All support functions will be provided through the Laboratory matrix organizational lines of authority and responsibility. The US CMS Project will also procure services, when cost effective, from the Laboratory's direct organizational units. The US CMS Project Manager will direct all questions of priority need for Laboratory support assistance not satisfied through normal lines of authority to the Laboratory Director.

10. Project Communications

The US CMS Project necessarily entails coordination between CERN, Fermilab, DOE and NSF. At the experiment level, CMS must coordinate with the US CMS collaboration. The US CMS Management Board serves as the interface between a given US CMS institution and the US CMS Project Office located at Fermilab. Lines of communication are schematically indicated in Fig. III-7.

The US CMS Project is conducted as a team effort involving DOE, NSF, CERN, Fermilab, CMS and US CMS. For the Project to progress rapidly, all parties need to be fully informed of progress, plans, issues, problems, solutions, and achievements in real time.

Communication among participants is free and informal to the maximum extent feasible. Notes, “drafts,” phone calls, electronic mail, and informal discussions are exchanged frequently among the participants to accomplish information flow, raise issues for mutual resolution, and explore the viability of plans and solutions. Distribution of copies of informal correspondence to all participants is desirable to keep them fully apprised of these communications. Each organizational participant will designate an individual to coordinate informal communications and assure their proper distribution within that organization.

Formal communication of project business flows through channels. Action on and transmittal of formal communications are performed promptly. On most issues, informal communication will have occurred prior to formal communication to minimize surprise and delay and maximize success.

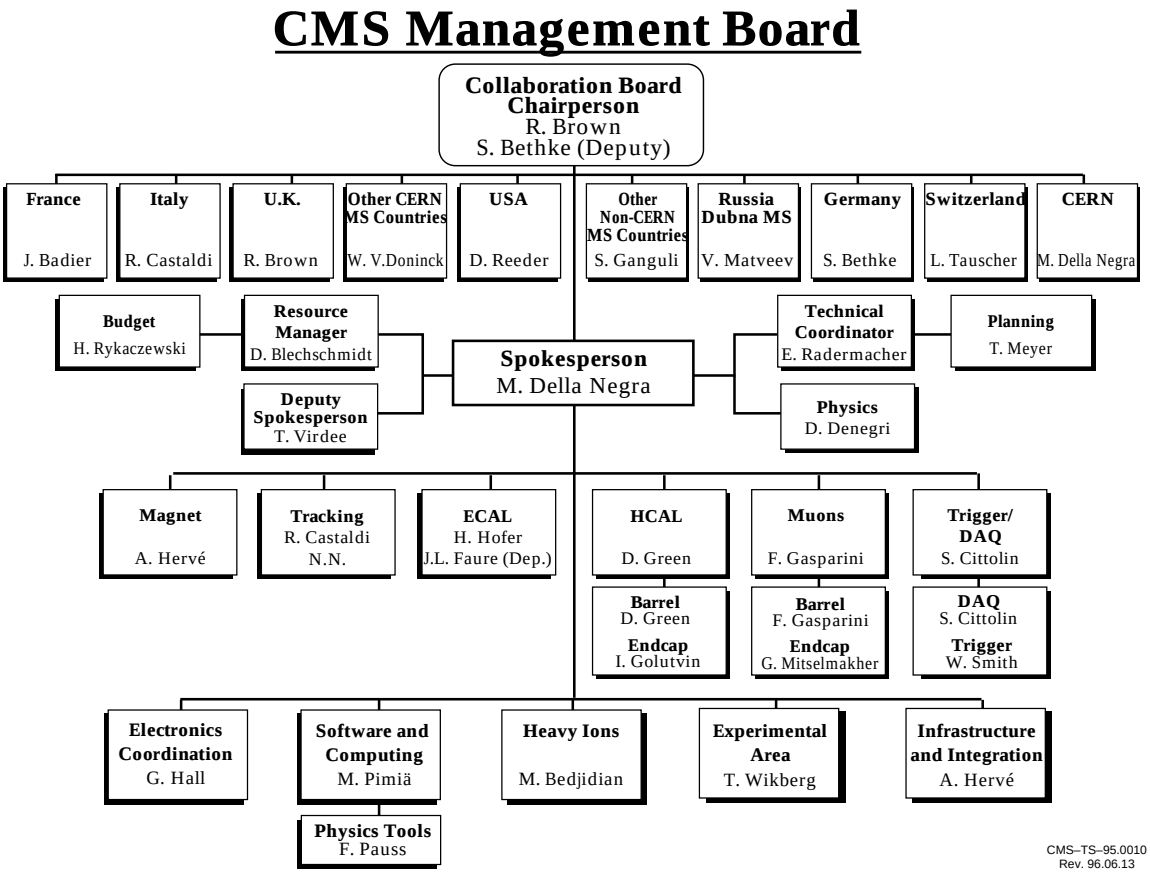
CMS Management Board
Collaboration Board Chairperson
R. Brown
S. Bethke (Deputy)
France
J. Badier
Italy
R. Castaldi
U.K.
R. Brown
Other CERN MS Countries
W. V.Doninck
USA
D. Reeder
Other Non-CERN MS Countries
S. Ganguli
Russia Dubna MS
V. Matveev
Germany
S. Bethke
Switzerland
L. Tauscher
CERN
M. Della Negra
Budget
H. Rykaczewski
Resource Manager
D. Blechschmidt
Deputy Spokesperson
T. Virdee
Spokesperson
M. Della Negra
Technical Coordinator
E. Radermacher
Planning
T. Meyer
Physics
D. Denegri
Magnet
A. Hervé
Tracking
R. Castaldi
N.N.
ECAL
H. Hofer
J.L. Faure (Dep.)
HCAL
D. Green
Barrel
D. Green
Endcap
I. Golutvin
Muons
F. Gasparini
Barrel
F. Gasparini
Endcap
G. Mitselmakher
Trigger/ DAQ
S. Cittolin
DAQ
S. Cittolin
Trigger
W. Smith
Electronics Coordination
G. Hall
Software and Computing
M. Pimiä
Physics Tools
F. Pauss
Heavy Ions
M. Bedjidian
Experimental Area
T. Wikberg
Infrastructure and Integration
A. Hervé
CMS–TS–95.0010
Rev. 96.06.13

Fig. III-1

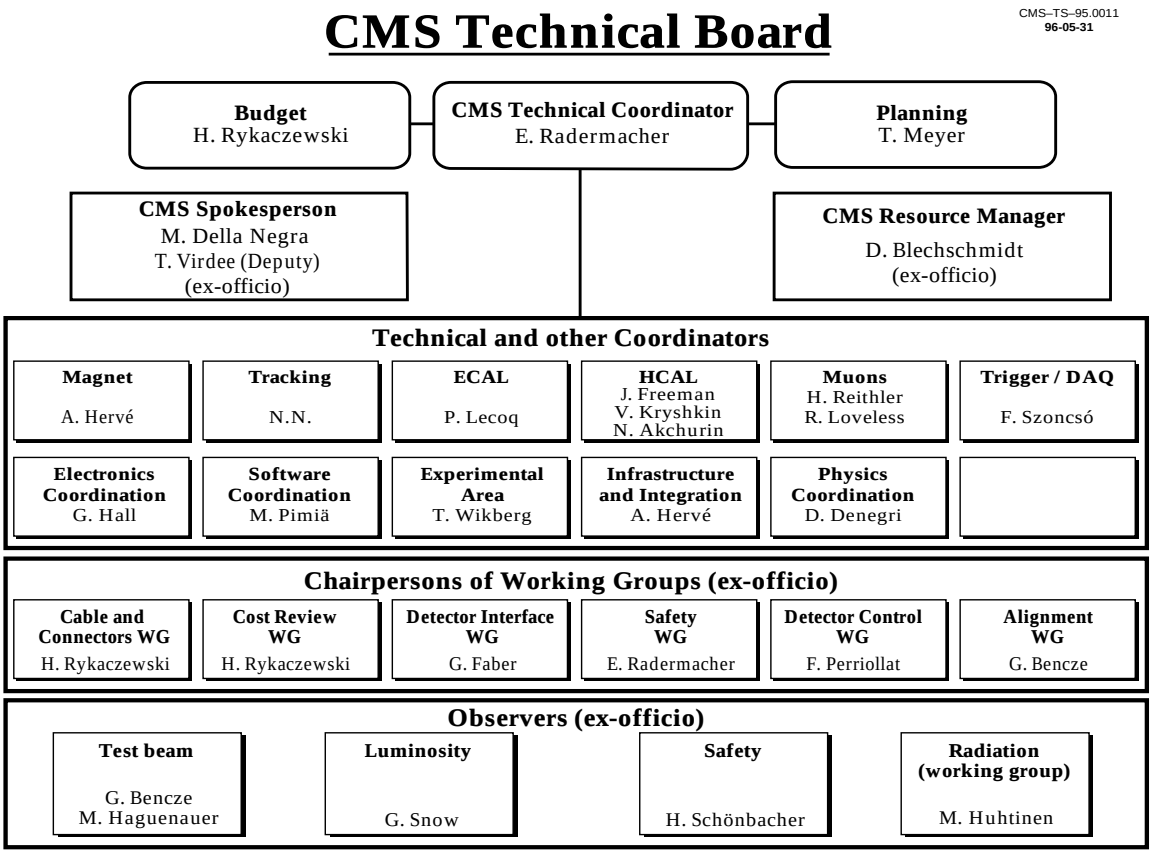
CMS Technical Board
CMS–TS–95.0011
96-05-31
Budget
H. Rykaczewski
CMS Technical Coordinator
E. Radermacher
Planning
T. Meyer
CMS Spokesperson
M. Della Negra
T. Virdee (Deputy)
(ex-officio)
CMS Resource Manager
D. Blechschmidt
(ex-officio)
Technical and other Coordinators
Magnet
A. Hervé
Tracking
N.N.
ECAL
P. Lecoq
HCAL
J. Freeman
V. Kryshkin
N. Akchurin
Muons
H. Reithler
R. Loveless
Trigger / DAQ
F. Szoncsó
Electronics Coordination
G. Hall
Software Coordination
M. Pimiä
Experimental Area
T. Wikberg
Infrastructure and Integration
A. Hervé
Physics Coordination
D. Denegri
Chairpersons of Working Groups (ex-officio)
Cable and Connectors WG
H. Rykaczewski
Cost Review WG
H. Rykaczewski
Detector Interface WG
G. Faber
Safety WG
E. Radermacher
Detector Control WG
F. Perriollat
Alignment WG
G. Bencze
Observers (ex-officio)
Test beam
G. Bencze
M. Haguenauer
Luminosity
G. Snow
Safety
H. Schönbacher
Radiation (working group)
M. Huhtinen

Fig. III-2

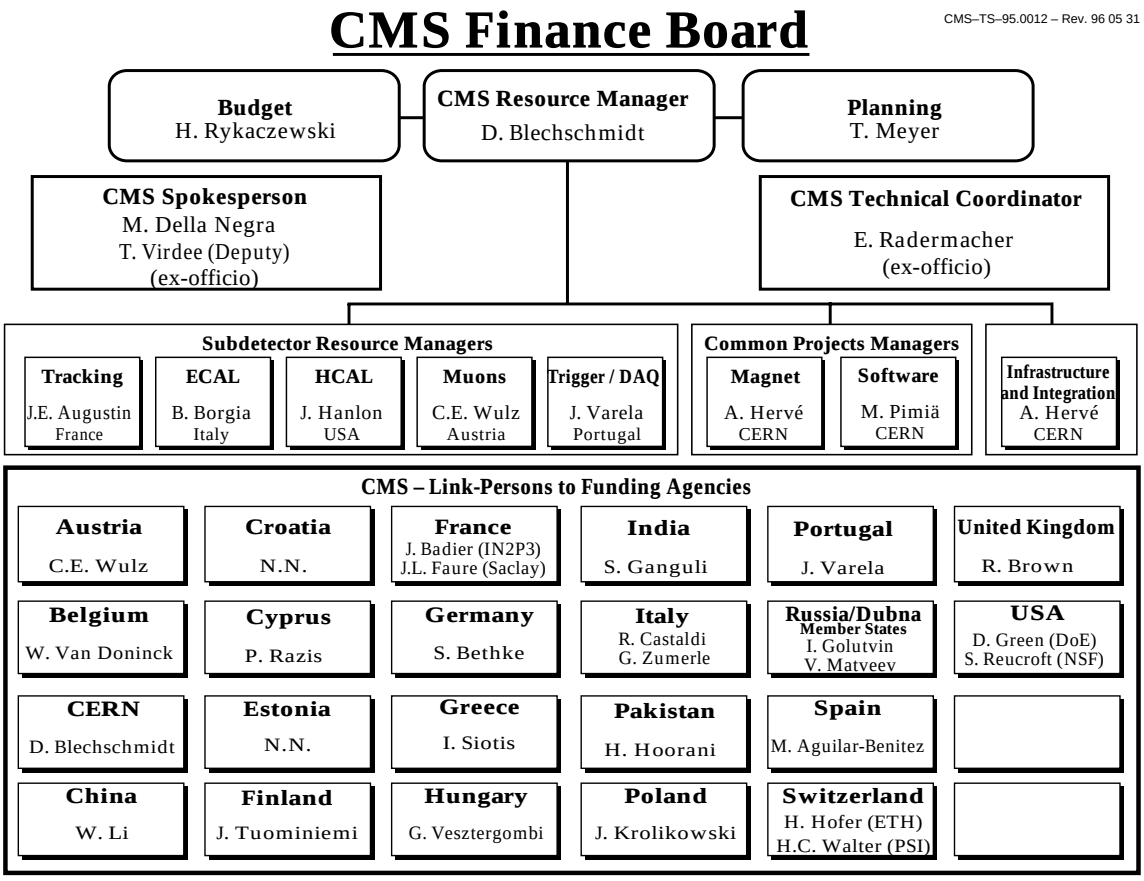
CMS Finance Board
CMS–TS–95.0012 – Rev. 96 05 31
Budget
H. Rykaczewski
CMS Resource Manager
D. Blechschmidt
Planning
T. Meyer
CMS Spokesperson
M. Della Negra
T. Virdee (Deputy)
(ex-officio)
CMS Technical Coordinator
E. Radermacher
(ex-officio)
Subdetector Resource Managers
Tracking
J.E. Augustin
France
ECAL
B. Borgia
Italy
HCAL
J. Hanlon
USA
Muons
C.E. Wulz
Austria
Trigger / DAQ
J. Varela
Portugal
Common Projects Managers
Magnet
A. Hervé
CERN
Software
M. Pimiä
CERN
Infrastructure and Integration
A. Hervé
CERN
CMS – Link-Persons to Funding Agencies
Austria
C.E. Wulz
Croatia
N.N.
France
J. Badier (IN2P3)
J.L. Faure (Saclay)
India
S. Ganguli
Portugal
J. Varela
United Kingdom
R. Brown
Belgium
W. Van Doninck
Cyprus
P. Razis
Germany
S. Bethke
Italy
R. Castaldi
G. Zumerle
Russia/Dubna Member States
I. Golutvin
V. Matveev
USA
D. Green (DoE)
S. Reucroft (NSF)
CERN
D. Blechschmidt
Estonia
N.N.
Greece
I. Siotis
Pakistan
H. Hoorani
Spain
M. Aguilar-Benitez
China
W. Li
Finland
J. Tuominiemi
Hungary
G. Vesztergombi
Poland
J. Krolikowski
Switzerland
H. Hofer (ETH)
H.C. Walter (PSI)

Fig. III-3

US CMS Management Board

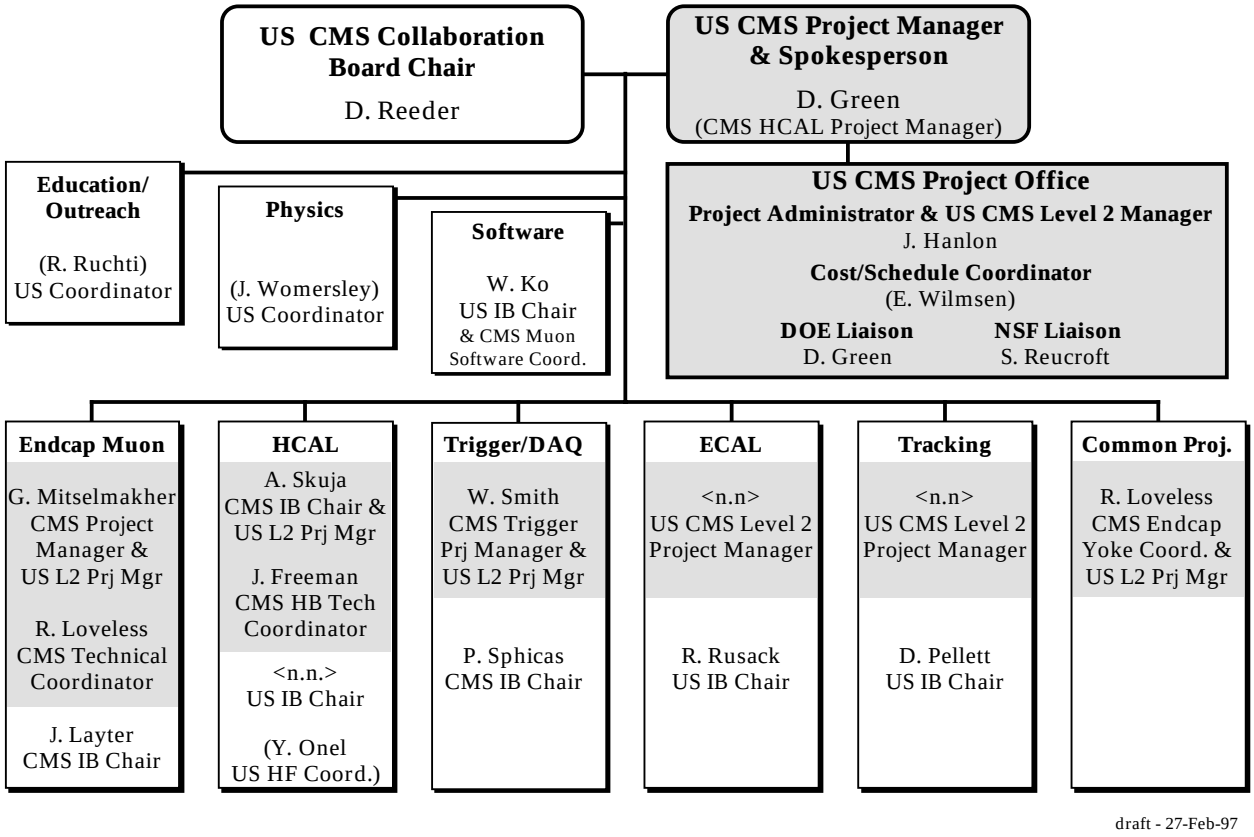

Fig. III-4

US CMS Project Office

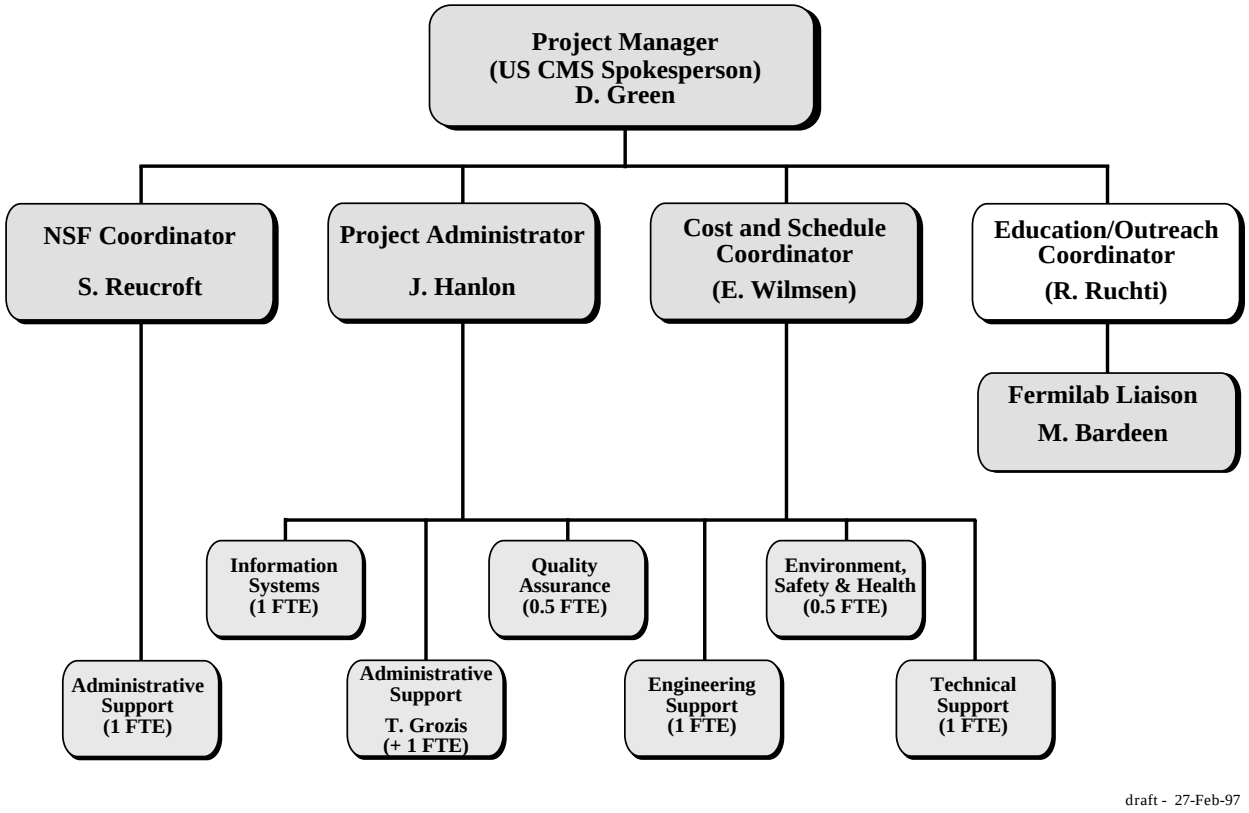

Fig. III-5

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Fig. III-6

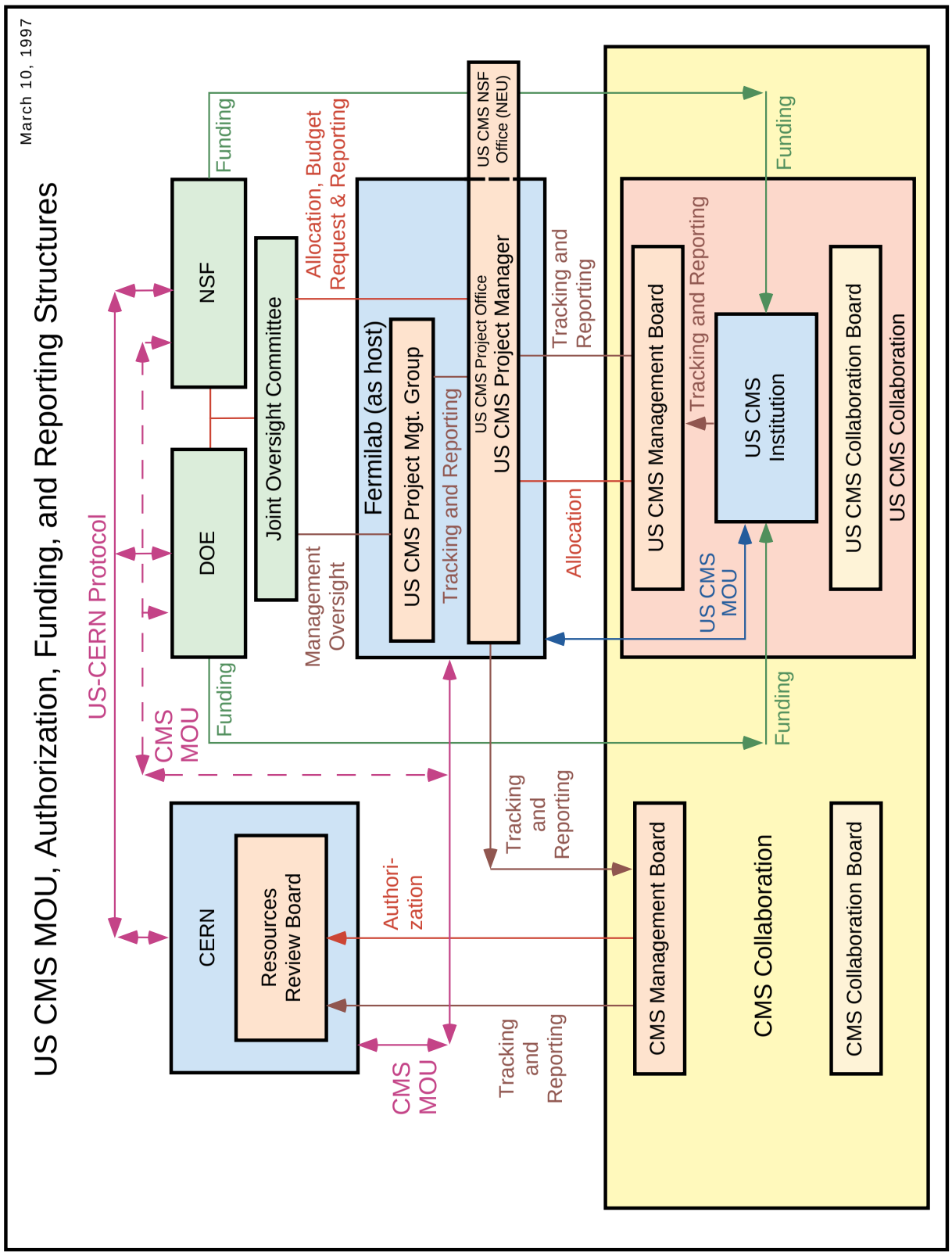

US CMS MOU, Authorization, Funding, and Reporting Structures
March 10, 1997
US-CERN Protocol
CMS MOU
NSF
DOE
Funding
Joint Oversight Committee
Allocation, Budget Request & Reporting
Management Oversight
Fermilab (as host)
US CMS Project Mgt. Group
Tracking and Reporting
US CMS NSF Office (NEU)
US CMS Project Office
US CMS Project Manager
Tracking and Reporting
Allocation
US CMS Management Board
Tracking and Reporting
US CMS Institution
US CMS Collaboration Board
US CMS Collaboration
US CMS MOU
Funding
CERN
Resources Review Board
Authori-zation
Tracking and Reporting
CMS MOU
CMS Management Board
CMS Collaboration
CMS Collaboration Board

Fig. III-7

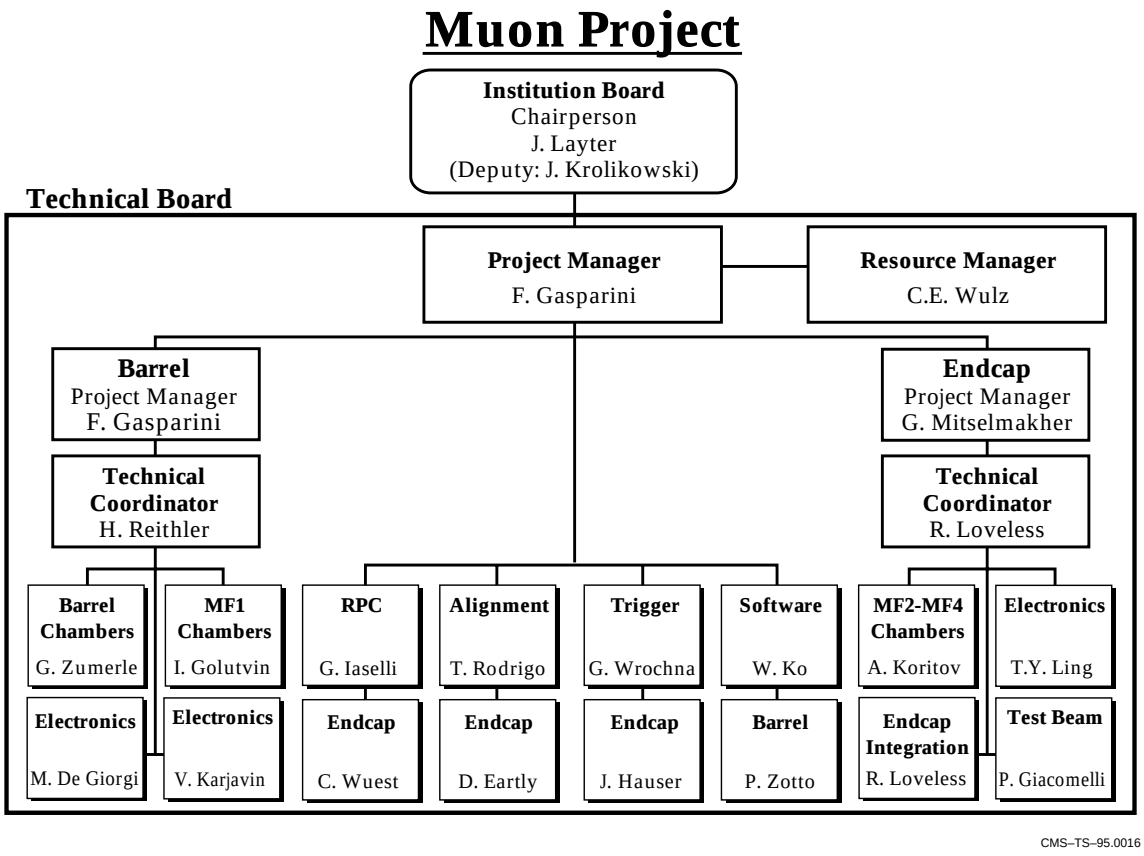

Muon Project
Institution Board
Chairperson
J. Layter
(Deputy: J. Krolikowski)
Technical Board
Project Manager
F. Gasparini
Resource Manager
C.E. Wulz
Barrel
Project Manager
F. Gasparini
Endcap
Project Manager
G. Mitselmakher
Technical Coordinator
H. Reithler
Technical Coordinator
R. Loveless
Barrel Chambers
G. Zumerle
MF1 Chambers
I. Golutvin
RPC
G. Iaselli
Alignment
T. Rodrigo
Trigger
G. Wrochna
Software
W. Ko
MF2-MF4 Chambers
A. Koritov
Electronics
T.Y. Ling
Electronics
M. De Giorgi
Electronics
V. Karjavin
Endcap
C. Wuest
Endcap
D. Eartly
Endcap
J. Hauser
Barrel
P. Zotto
Endcap Integration
R. Loveless
Test Beam
P. Giacomelli
CMS–TS–95.0016

Fig. III-8

HCAL Project

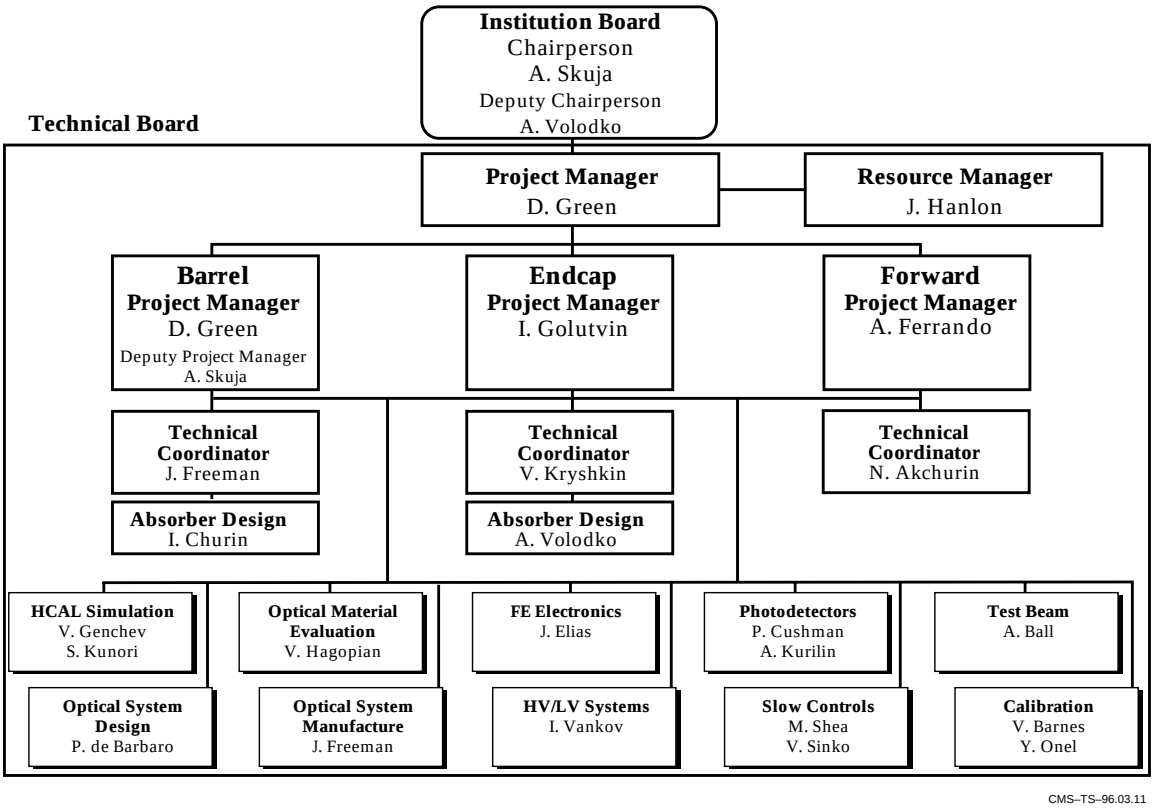


Fig. III-9

Trigger and Data Acquisition Project

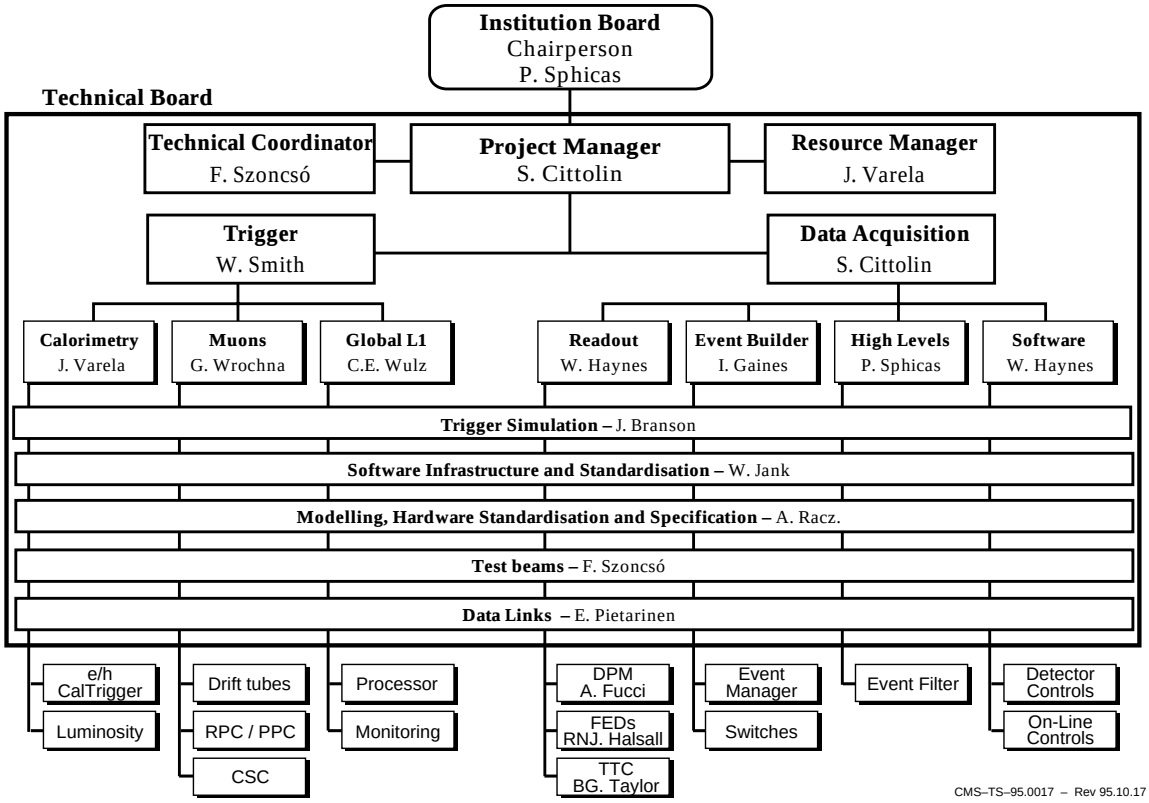


Fig. III-10

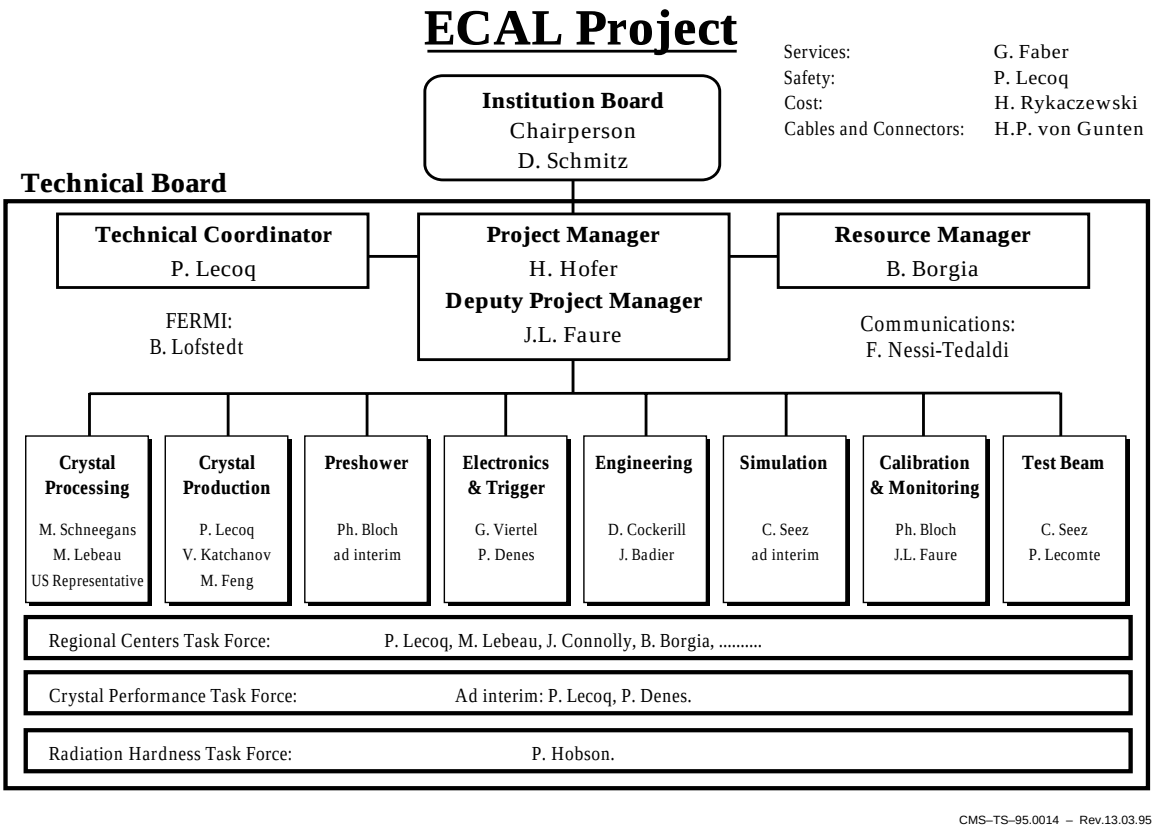

ECAL Project
Services: G. Faber
Safety: P. Lecoq
Cost: H. Rykaczewski
Cables and Connectors: H.P. von Gunten
Institution Board
Chairperson
D. Schmitz
Technical Board
Technical Coordinator
P. Lecoq
Project Manager
H. Hofer
Deputy Project Manager
J.L. Faure
Resource Manager
B. Borgia
FERMI:
B. Lofstedt
Communications:
F. Nessi-Tedaldi
Crystal Processing
M. Schneegans
M. Lebeau
US Representative
Crystal Production
P. Lecoq
V. Katchanov
M. Feng
Preshower
Ph. Bloch
ad interim
Electronics & Trigger
G. Viertel
P. Denes
Engineering
D. Cockerill
J. Badier
Simulation
C. Seez
ad interim
Calibration & Monitoring
Ph. Bloch
J.L. Faure
Test Beam
C. Seez
P. Lecomte
Regional Centers Task Force: P. Lecoq, M. Lebeau, J. Connolly, B. Borgia, ...
Crystal Performance Task Force: Ad interim: P. Lecoq, P. Denes.
Radiation Hardness Task Force: P. Hobson.
CMS–TS–95.0014 – Rev.13.03.95

Fig. III-11

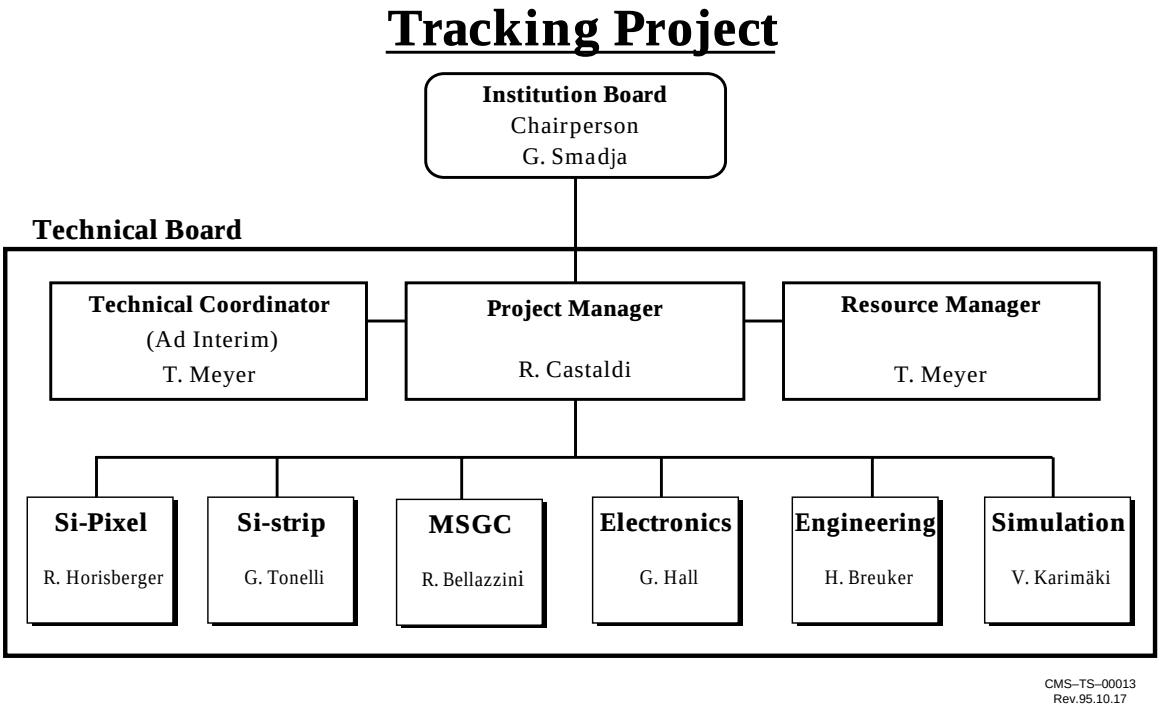

Tracking Project
Institution Board
Chairperson
G. Smadja
Technical Board
Technical Coordinator
(Ad Interim)
T. Meyer
Project Manager
R. Castaldi
Resource Manager
T. Meyer
Si-Pixel
R. Horisberger
Si-strip
G. Tonelli
MSGC
R. Bellazzini
Electronics
G. Hall
Engineering
H. Breuker
Simulation
V. Karimäki
CMS–TS–00013
Rev.95.10.17

Fig. III-12

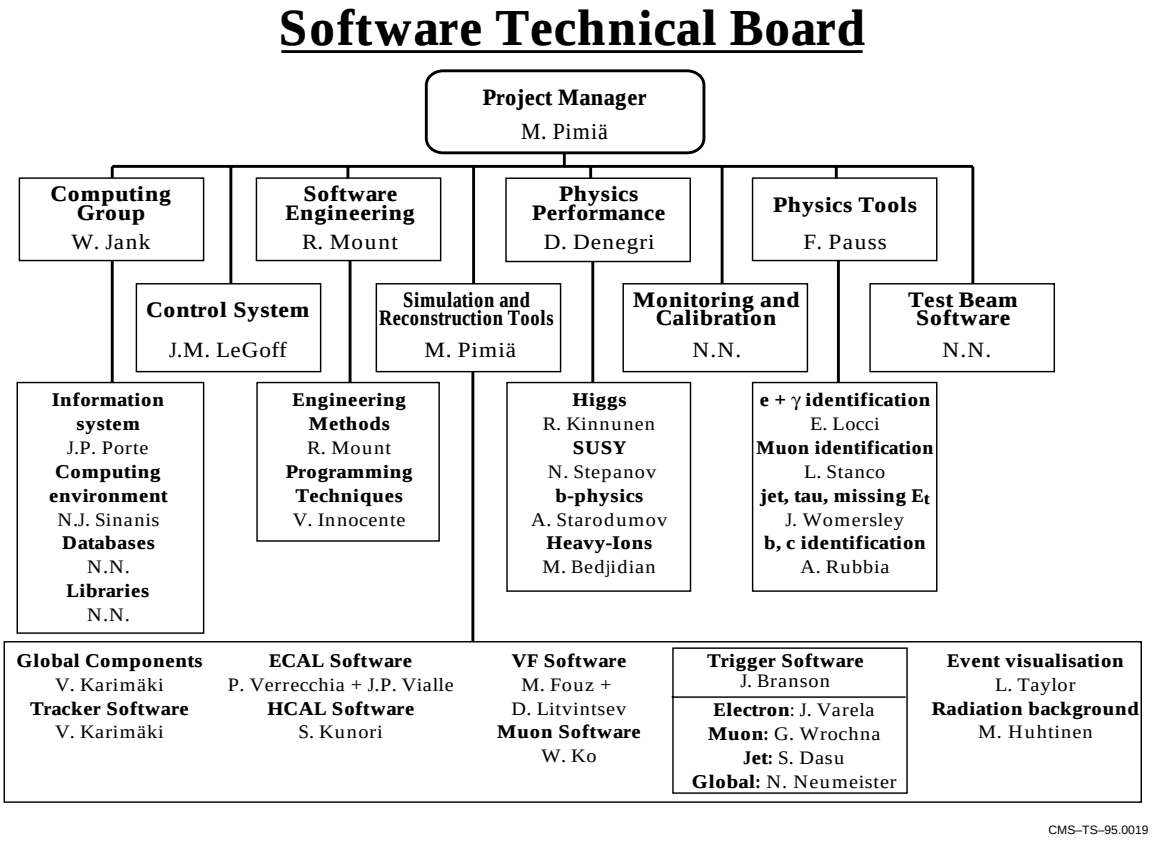

Software Technical Board
Project Manager
M. Pimiä
Computing Group
W. Jank
Software Engineering
R. Mount
Physics Performance
D. Denegri
Physics Tools
F. Pauss
Control System
J.M. LeGoff
Simulation and Reconstruction Tools
M. Pimiä
Monitoring and Calibration
N.N.
Test Beam Software
N.N.
Information system
J.P. Porte
Computing environment
N.J. Sinanis
Databases
N.N.
Libraries
N.N.
Engineering Methods
R. Mount
Programming Techniques
V. Innocente
Higgs
R. Kinnunen
SUSY
N. Stepanov
b-physics
A. Starodumov
Heavy-Ions
M. Bedjidian
e + γ identification
E. Locci
Muon identification
L. Stanco
jet, tau, missing Et
J. Womersley
b, c identification
A. Rubbia
Global Components
V. Karimäki
Tracker Software
V. Karimäki
ECAL Software
P. Verrecchia + J.P. Vialle
HCAL Software
S. Kunori
VF Software
M. Fouz +
D. Litvintsev
Muon Software
W. Ko
Trigger Software
J. Branson
Electron: J. Varela
Muon: G. Wrochna
Jet: S. Dasu
Global: N. Neumeister
Event visualisation
L. Taylor
Radiation background
M. Huhtinen
CMS–TS–95.0019

Fig. III-13

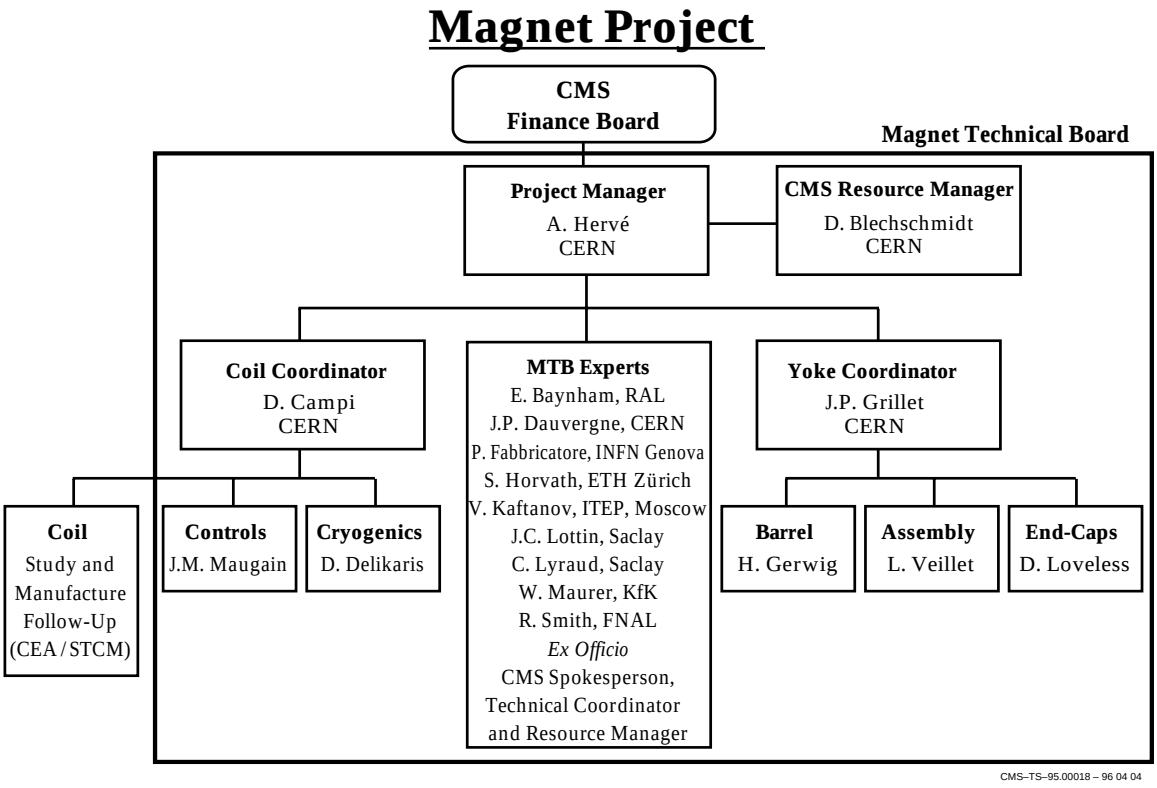

Magnet Project
CMS
Finance Board
Magnet Technical Board
Project Manager
A. Hervé
CERN
CMS Resource Manager
D. Blechschmidt
CERN
Coil Coordinator
D. Campi
CERN
MTB Experts
E. Baynham, RAL
J.P. Dauvergne, CERN
P. Fabbricatore, INFN Genova
S. Horvath, ETH Zürich
V. Kaftanov, ITEP, Moscow
J.C. Lottin, Saclay
C. Lyraud, Saclay
W. Maurer, KfK
R. Smith, FNAL
Ex Officio
CMS Spokesperson,
Technical Coordinator
and Resource Manager
Yoke Coordinator
J.P. Grillet
CERN
Coil
Study and
Manufacture
Follow-Up
(CEA / STCM)
Controls
J.M. Maugain
Cryogenics
D. Delikaris
Barrel
H. Gerwig
Assembly
L. Veillet
End-Caps
D. Loveless
CMS–TS–95.00018 – 96 04 04

Fig. III-14

Section IV

Work Plan

IV. Work Plan

A. Introduction

In this chapter, the work to be performed in the US CMS Project is described in Section IV.B, and the methodology to be used in the execution of the work is described in Section IV.C. The research and development (R&D) program connected with the US CMS Project is described in Section IV.D. System tests and commissioning are discussed in Section IV.E. The final two sections of this chapter describe the programs to be utilized by the US CMS Project for Quality Assurance (Section IV.F) and for Safety Analysis and Compliance and Environmental Compliance (Section IV.G).

B. Work Description

This project provides for the construction of elements of an experiment to be performed at CERN, designated the US CMS Project. The purpose of the project is described in Section II.A. The salient features of the work that needs to be done are briefly described in Section II of this plan, and in considerable detail in the CMS Technical Design Reports.

C. Work Execution

[to be completed after full project scope is known]

Design and Engineering

Construction, Fabrication, Assembly, and Installation

Inspection and Acceptance

D. Research and Development Program

A program of R&D in support of the US CMS construction project has already been initiated. This program will provide for the design and development of new detector components and for the fabrication and testing of prototypes. R&D directed towards the optimization of performance and cost will continue through the early years of construction. The DOE funded efforts in R&D will be done largely in FY96 and FY97. The NSF funded efforts will occur largely FY96, FY97, and FY98. The scope of the FY96 efforts in R&D undertaken by the US CMS collaboration are discussed in the US CMS Project Update. The R&D program has been developed to interface with the construction project milestones.

The R&D effort will be managed by the US CMS Project Manager. Coordination of the R&D work with the construction schedule will be the responsibility of the US CMS Project Manager with the advice and consent of the US CMS Management Board.

E. System Tests and Commissioning

[to be completed after full project scope is known]

F. Quality Assurance Program

Quality assurance is an integral part of the design, procurement, fabrication, and construction phases of the US CMS Project. Special attention is being devoted to items that will affect the performance capability and operation of the CMS detectors.

It is the policy of the US CMS project that all activities shall be performed at a level of quality appropriate to achieving the technical, cost, and schedule objectives of the project. To implement this policy, the US CMS project will develop a SQIP that is based on the QA criteria established by DOE and NSF. The responsible person for the QAP for the US CMS is the US CMS Project Manager.

The US CMS project SQIP will define the management policies in regard to 1) QA program, 2) Personnel Training and Qualification, 3) Quality Improvement, 4) Documents and Records, 5) Work Processes, 6) Design, 7) Procurement, 8) Inspection and Acceptance Testing, 9) Management Assessment, and 10) Independent Verification.

Vendors will implement quality assurance programs appropriate to the services being furnished. These programs, as well as implementing procedures, are subject to review and audit by the US CMS Project Office at Fermilab.

G. Environment, Safety and Health Analysis and Compliance

Implementation of the project ES&H program is the responsibility of the US CMS Project Manager and the line managers in the US CMS organization. The US CMS Project Manager has appointed the US CMS Project Administrator to be the US CMS ES&H Supervisor with the responsibility to monitor the implementation of the total US CMS project ES&H program to ensure conformance and to be responsible for coordination of the project-wide ES&H program.

All project activities will be conducted in compliance with the applicable DOE and NSF ES&H directives.

Section V

Work Breakdown Structure

V. Work Breakdown Structure

All work required for successful completion of the US CMS Project is organized into a WBS. The WBS contains a complete definition of the scope of the project and forms the basis for planning, execution, and control of the US CMS Project. The US CMS WBS is continued to a sufficiently low level to make each deliverable and its provider unique and trackable. Specifically, the WBS provides the framework for the following activities:

Budgeting

Each element of the WBS is assigned a budgeted cost (BC). The budgeted cost of the project can be seen at any level by performing a sum over contributing lower levels.

Cost Estimating

The WBS supports a systematic approach to preparation of the cost estimate for the project. The WBS structure is extended to a level sufficient to allow definition of individual components for which a cost can be reasonably estimated. The BC and cost estimate are equal for the lowest level in each branch of the WBS.

Scheduling

The WBS also supports a systematic approach to preparation of the project schedule. Again each WBS element at the lowest level of the structure is assigned a schedule duration. The project schedule is created by establishing the interdependencies between the various elements.

Support Requirements

The WBS, in conjunction with the associated schedule and cost estimates, provides the framework for projecting funding and manpower requirements over the life of the project.

Configuration Control

The detailed scope of the project is specified within the WBS. Impacts of proposed changes to the scope are readily evaluated within the WBS framework.

Performance Measurement

The WBS supports the monitoring, control, and reporting of cost and schedule performance. Since each element of the WBS, and by association each work element, has a well defined BC and schedule a view of the progress of the project at any level is available at any time.

A. Organization of the WBS

The levels of the WBS reflect the logical breakdown of the work required to complete the project with lower levels providing progressively higher levels of detailed description. The number of levels is established by extending the description down to a level at which individual components can be identified and associated into a well defined piece of equipment or structure.

B. Project Summary WBS

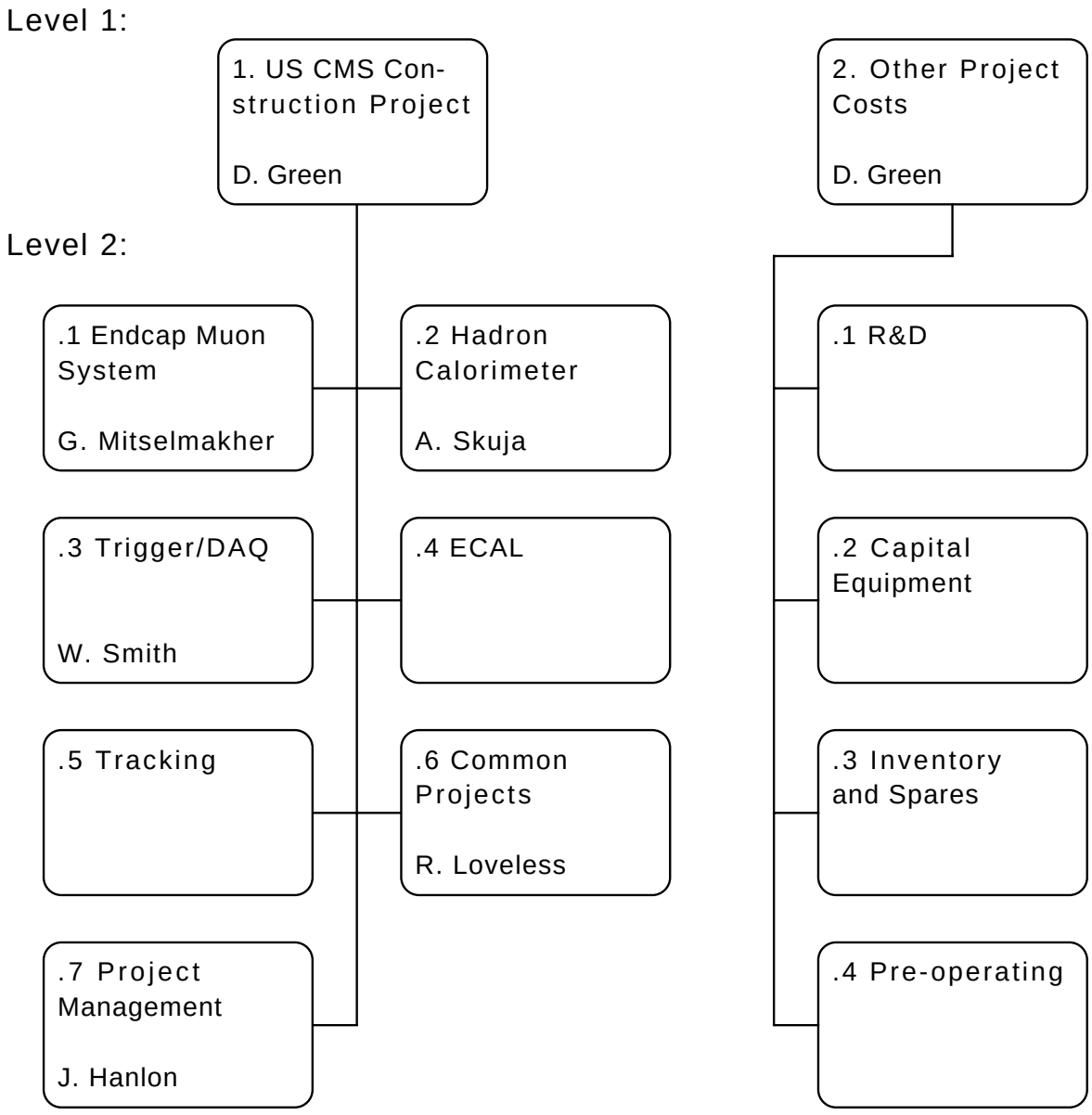
The Project Summary WBS is a consolidation of the top three levels of the US CMS Construction Project WBS, and the top two levels associated with Other Project Costs - R&D, Capital Equipment, Inventories and Spares, and Pre-operating costs. The specific Project Summary WBS is given below.

1. US CMS Construction Project
    - 1.1 Endcap Muon Systems
        - 1.1.1 Muon Measurement System
    - 1.2 Hadron Calorimeter
        - 1.2.1 Barrel Hadron Calorimeter
        - 1.2.2 Endcap Hadron Calorimeter
        - 1.2.3 Forward Calorimeter
    - 1.3 Trigger/DAQ
        - 1.3.1 Endcap Muon Level 1 Trigger
        - 1.3.2 Calorimeter Level 1 Trigger
        - 1.3.3 Luminosity Monitor
        - 1.3.4 Data Acquisition
    - 1.4 Electromagnetic Calorimeter
        - 1.4.1 Barrel Photodetectors
        - 1.4.2 Very Front-end Electronics
        - 1.4.3 Crystal Processing
        - 1.4.4 Monitoring Light Source
    - 1.5 Tracking
        - 1.5.1 Pixel Tracker
    - 1.6 Common Projects
    - 1.7 Project Management
        - 1.7.1 Project Administration
        - 1.7.2 Technical Coordination

2. Other Project Costs
    - 2.1 R&D
    - 2.2 Capital Equipment
    - 2.3 Pre-operating
    - 2.4 Inventories and Spares

The highest levels of the Project Summary WBS are shown in Table V-1.

Table V-1: Project Summary WBS, and WBS Level 2 Managers



C. WBS Dictionary

The WBS Level 2 Managers are shown in Table V-1. A narrative description of the third level elements is given below for the construction portion of the project, and of the second level elements for other project costs.

1.1.1 Muon Measurement System

Includes the design, procurement, fabrication, and contract labor required to construct detection elements of the CMS endcap muon measurement system.

1.2.1 Barrel Hadron Calorimeter

Includes the design, procurement, fabrication, and contract labor required to construct the CMS barrel hadron calorimeter system.

1.2.2 Endcap Hadron Calorimeter

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS endcap hadron calorimeter system.

1.2.3 Forward Calorimeter

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS forward calorimeter system.

1.3.1 Endcap Muon Level 1 Trigger

Includes the design, procurement, fabrication, and contract labor required to construct the CMS endcap muon level 1 trigger system.

1.3.2 Calorimeter Level 1 Trigger

Includes the design, procurement, fabrication, and contract labor required to construct the CMS calorimeter level 1 trigger system.

1.3.3 Data Acquisition

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS data acquisition system.

1.3.4 Luminosity Monitor

Includes the design, procurement, fabrication, and contract labor required to construct the CMS luminosity monitor system.

1.4.1 Photodetectors

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS ECAL photodetector system.

1.4.2 Electronics

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS ECAL electronics system.

1.4.3 Crystals

Includes the design, procurement, fabrication, and contract labor required to construct the CMS ECAL crystal laser monitoring system.

1.5.1 Pixel Tracker

Includes the design, procurement, fabrication, and contract labor required to construct the CMS forward pixel tracker system.

1.6.1 Magnet

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS magnet system for which the US is responsible.

1.6.2 Off-line Systems

Includes the design, procurement, fabrication, and contract labor required to construct elements of the CMS off-line system for which the US is responsible.

1.7.x Project Management

Includes management of the US CMS Project.

2.1 Direct R&D Operating Costs

Provides for the design and development of new detector components and for the fabrication and testing of prototypes. R&D directed toward the optimization of performance and cost will continue through the early years of construction.

2.2 Capital Equipment

Includes test instruments, electronics and other general equipment.

2.3 Inventories and Spares

Provides for spares for the major technical components.

2.4 Pre-operating Costs

Includes personnel costs for a commissioning period.

Section VI

Project Schedule and Milestones

VI. PROJECT SCHEDULE AND MILESTONES

A. Schedule Baseline

The schedule baseline sets forth the major activities, decision points and activity interfaces essential for completion of the US CMS Project.

The baseline schedule includes interpretation and optimization of activities related to the design, procurement, fabrication, assembly, testing, installation and checkout of detector elements. The Project Master Schedule will be developed to include major activities and decision points. It is composed of major WBS level 3 elements with significant milestones included. This schedule will be the top level project schedule and is the basis for baseline development in all lower level project schedules.

Work package schedules at the lowest WBS level (L7) will be assembled into an interconnected activity logic diagram by integrating construction activities within each respective WBS element. Schedule interfaces with other WBS elements will be made. This integrated schedule provides a total project critical path. Summarization of these lower level activities allows status to be rolled up through the various WBS levels to provide intermediate level and master level working schedules. These working schedule dates are compared to the established baseline dates and any variances addressed in the Progress Reports. Consistency of data from work packages through intermediate schedules to the master schedule will be traced through control and event milestones. All milestones contained in the Project Master Schedule are reflected in the lower level schedules.

The schedule management and monitoring system will be developed using commercially available software. The schedule status is summarized at the various WBS levels, to provide project schedule reporting at the master, intermediate, and detailed levels by WBS and across functional organizations. The master level schedule will also include a critical path.

The present highest level schedule for CMS is given in Fig. II-1.

B. Baseline Milestones

A set of project milestones for L1 schedule has been defined by the US CMS Collaboration, in consultation with the CERN LHC experiments Committee (LHCC). The L1 and L2 schedule for US CMS is given in Table VI-1. The corresponding CMS milestones appear in the CMS Interim MOU.

Table VI-1: US CMS Level 2 Schedules

insert L1 and L2 here

Section VII

Cost and Labor Estimates

VII. Cost and Labor Estimates

A. Cost Baseline

The cost baseline will be established on June 2-5, 1997 when the Project Plan is reviewed. The project cost baseline is equal to the sum of the budgeted costs for each element of the Work Breakdown Structure described in Section V. Changes in cost, technical requirements, schedules, and plans are to be treated as variances to the baseline.

The TEC of the US CMS project is $174M in then-year dollars. Included in the TEC are procurement, assembly, and installation of all technical components, engineering design, inspection, and project management required to assure successful completion of the project. Contingency funds in the amount of 30% of the base cost, excluding common projects, are also included in the TEC as is a $26M allowance for escalation. The TPC is $174M which includes $2.5M of R&D, capital equipment, pre-operations and spares.

B. Obligations and Cost Plans in FY 1996 Dollars

The construction cost estimate is maintained in fixed year (FY 1996) dollars. The TEC in FY 1996 dollars is $146M.

C. Escalation

Escalation rates are based upon an assumed annual escalation rate given by guidance from OMB.

D. Budget Authority and Funding Profile

The project baseline schedule, obligations and cost plan will be based on the best estimate of the funding profile. The obligation plan will be derived from the baseline schedule and cost plans given in this Project Management Plan. Similarly, application of the escalation rates given in C above will result in the cost plan.

E. Labor Requirements

Labor requirements have been estimated for each work package in the US CMS project. These estimates include the required EDIA and Fermilab-based project management, as well as manufacturing labor.

Section VIII

Work Authorization and Project Control System

VIII. Work Authorization and Project Control System

A. Introduction

This section summarizes the management systems that the US CMS Project Manager will use to manage the cost and schedule performance and the technical accomplishments of the Project relative to this PMP. The significant interfaces that exist among the various management systems are noted in the individual narrative descriptions below. Although these systems are described separately they are mutually supportive and will be employed in an integrated manner in order to achieve the project objectives. As conditions change during the evolution of the project, the management systems will be modified appropriately so as to remain responsive to the needs for project control and reporting. Consequently, while the policy and objectives of each management system will remain fixed, the methods, techniques, and procedures that will be employed by the US CMS Project are expected to change as conditions dictate, over the life of the project.

The Work Authorization and Contingency Management System and the Project Control System described in this chapter defines the management and control procedures which are needed to comply with the requirements of DOE and NSF and Fermilab.

B. Guidelines and Policies

The Work Authorization and Contingency Management System and the Project Control System employed by the US CMS Project will be consistent with DOE and NSF guidelines .

The following policies are applicable for the US CMS:

- All Project work is organized in accordance with the WBS.
- Formal (and informal) reviews by experts are used to obtain official specifications and designs.
- Established cost, schedule, and technical baselines are used for measuring project performance.
- Changes to the approved cost, schedule, and technical baselines proceed via a Change Request (CR) process described below.
- A project management system, which features performance measurement and critical-path scheduling, is used to control the project and to provide forecast and feedback information to management.

- The decision making apparatus employs regular meetings among the US CMS organizational elements. These meetings will serve to identify and resolve interface issues within the project.

- Quality assurance, safety analysis and review, and environment assessment are integral parts of the Work Authorization and Project Control.

C. Work Authorization and Contingency Management

Funds will be made available by the DOE and NSF for support of the US CMS project on an annual basis. Requests for specific amounts, identified at level 3 of the WBS, will be prepared by the US CMS Project Manager. Each such request will include a description of the work to be performed, the requested funds, the forecast cost of the work, and the currently projected contingency requirement at WBS level 3, over the life of the project. Funds will then be released to the institutions who are part of the US CMS Collaboration. A management reserve of no more than 30% of the annual budget will be held by the Project Manager and will be applied during the fiscal year on the basis of performance and need, as discussed in Section III.D.1.

The PMG, chaired by the Fermilab Director or his/her designee, will act as the Change Control Board for the US CMS Project. The PMG will have as its purview assignment of contingency funds and any change of the scope of the project. Scope changes would arise should projected costs exceed the assigned contingency of any L2 system.

At any time the project contingency is the difference between the project TEC and the sum of the current Estimates at Completion (EAC) at level 3 of the WBS. The contingency is help by the PM. The contingency funds are allocated through the project change control. The PM and the PMG would jointly attempt to either descope the effort in question or assign contingency funds from another portion of the full US CMS Project should costs exceed contingency allocations.

The principles of contingency management that the US CMS project will follow are as follows:

- The cost estimate for each L2 subsystem will include contingency funds based on an assessment of uncertainties and risks associated with the budgeted cost.

- The actual expenditure of contingency will be reflected in a revised EAC, updated annually.

- The Fermilab CMS PMG will approve all CRs that will require future utilization of contingency. A log of such approved requests will be maintained by the US CMS project office and the US CMS Fermilab PMG.

- The initial funding request of each fiscal year may, with the concurrence of the US CMS Fermilab PMG, assign 25% of the contingency available in that year to US CMS for application within the following guidelines:

- The US CMS Project Manager may adjust the budgeted cost of any WBS level 3 package by xx% or $yM, which ever is less, as long as the Project TEC is not exceeded.

- All changes from baseline cost shall be traceable.

The funds included in each funding request are under the authority of the US CMS Project Manager. Subject to the above conditions the US CMS Project Manager can request the PMG to authorize change requests without further DOE or NSF approval.

D. Project Control System

The Project Control System includes the three categories listed below:

- Baseline Development: This includes management actions necessary to define project scope and responsibilities, establish baselines, and plan the project.

- Project Performance: This includes management actions after work commences that are necessary to monitor project status, report and analyze performance, and manage risk.

- Change Management: This includes management actions necessary to ensure adequate control of project baselines, including the performance measurement baseline.

1. Baseline Development

Each L2 subsystem manager prepares a formal cost estimate and schedule.

2. Project Performance

Standard accounting practices and the Project Control System will collect costs for completed work. Performance analysis of costs, schedule, and work scope performance will provide a determination of project status. Each year the PM and L2 managers adjust the schedule so that the allocated funding is distributed optimally balancing cost and schedule considerations.

The actual cost of the project is captured in the Laboratory's General Ledger and is tracked by work packages based on the Work Breakdown Structure. In general, work packages are assigned to WBS Level 7 elements for cost collection. The

L2 managers are responsible to obtain reporting from their respective contributing institutions to track costs at that level.

Summary and detailed cost reports are prepared quarterly by the Project Management. Reports of costs and obligations for capital equipment funds are submitted to Laboratory management and the Department of Energy and NSF.

The principal functions of performance measurement and analysis are to identify, quantify, analyze, evaluate and rectify significant deviation from the baseline plan as early as possible.

Schedule Variance

At the end of each quarter, the milestone list and critical path tasks will be evaluated to identify deviations from the baseline schedule. Any deviations that have a significant impact on the project, either by delaying completion or by affecting the cost or labor plan of the project will be identified. A plan to rectify any delays will be developed and may include either alteration of the project schedule to optimize work and reduce delay or allocation of additional resources to shorten the time required to perform the tasks involved.

Any change that would alter the schedule, cost or required labor resources will be subject to change control as described in this plan.

Cost Variance

Quarterly cost variance will be determined by comparing the actual cost of work performed at WBS level 2 with the budgeted cost of work performed as represented in the current EAC. Cost variances that exceed the established thresholds are formally reported as required in this plan.

Resource Variance

A quarterly analysis of the resources available (labor and funds) will be performed to ensure that shortfalls in either which could lead to schedule and/or cost variances are identified in a timely manner and brought to the attention of the PMG.

3. Change Control

The US CMS Fermilab PM will control changes in requirements, cost, and schedule in consultation and agreement with the US CMS PMG. Any change that affects the interaction between detector subsystems or that significantly impacts the performance, schedule, or safety of the detector must also be referred to the CMS Technical and/or Management Board by the PM.

Out-of-Scope Changes

An Out-of-Scope Change is a proposed change to the US CMS Project that would alter the physics capabilities of the detector in a major way. This situation would occur if the costs for a given L2 subsystem were projected to exceed the limits of the assigned contingency. The PM is authorized to make adjustments of contingency across L2 boundaries. If such adjustment is not possible, the situation must be reported by the PMG and the PM to DOE and NSF and the CMS MB/TB respectively. Reducing the scope of the US CMS Project so as to remain within the TPC is the only allowable action. The scope reduction must be formulated to DOE, NSF and the PMG by the PM with the advice of the CMS MB/TB.

In-Scope Changes

Any change to the US CMS Project that does not alter the Scope of the Project as defined above does not require a new proposal to be submitted.

Although the Scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments or schedule impact are considered In-Scope Changes. Procedures for these changes are discussed in the following.

In Scope Changes - must have the approval of the US CMS PM.

In-Scope Changes that result in increases in the US CMS Project Estimate at Completion (EAC) must be initiated by a Change Request. Changes that result in increases in any level 2 WBS element, must be initiated by a Change Request (CR) form presented at the US CMS PMG. Such Requests will require the approval of the Deputy Director and/or Director as indicated below.

The US CMS PMG functions as the Baseline Change Control Board for the project. The US CMS Project Manager will maintain current records of all CRs and their disposition.

Notes

- The record of US CMS Project documentation revision status is maintained by the PM.
- The record of US CMS Project Management Group meetings will be maintained by the Directorate.
- A record of all CRs will be maintained by the US CMS Project Manager.
- All changes from baseline cost shall be traceable.

Section IX

Reporting And Review

IX. Reporting And Review

The CMS experiment reports to CERN as the responsible host of the experiment. In turn, the US CMS collaboration reports on technical progress to the full CMS collaboration. The US CMS PM is the point of contact with CERN and CMS on financial matters.

The institutions and personnel which comprise the US CMS collaboration are listed in Table IX-1.

The structure of tracking and reporting is shown in Fig. III-7. It begins with a report by the individual US CMS institution to the US CMS Management Board in the person of the relevant L2 manager. The reporting is passed to the PM and the project office which is responsible for tracking all US CMS funds. Reporting will be done at L7 in the WBS.

The US CMS Project Office is responsible for tracking and reporting all US CMS Project activities. The project office shall prepare and issue periodic reports of earned value and cost and schedule variance for the US CMS Project.

The US CMS PM reports both to the US CMS Fermilab PMG on the status of the US CMS Project, and in addition reports to the US funding agencies, DOE and NSF. The US CMS PM also reports to the CMS MB and FB on the status of the project. In turn, the CMS Management Board reports to the CERN Resource Review Board, whose members include DOE and NSF representatives.

The US CMS Management Board has full access to all tracking and reporting. This information will form the basis for continuing annual authorization of funds to a particular institution by the Project Manager with the advice and consent of the US CMS Management Board and with the concurrence of the US CMS Fermilab PMG.

Memoranda of Understanding will exist both within the CMS collaboration as a whole, and for the US CMS collaboration.

A Memorandum of Understanding (MOU) is to be negotiated between CERN as the host laboratory, the collaborating CMS institutions (represented by the CMS Collaboration Board) and their funding agencies (DOE and NSF in the US). A draft of an Interim MOU covering the initial phase of the CMS experiment has been signed for the 1996 and 1997 period of R&D. The US CMS PM will be a signatory to the MOU, with the Fermilab Director concurring in the MOU.

Within the US CMS Project, a second detailed US MOU will be executed. A draft version of this MOU and of the annual SOW have been written, and appear here as Appendices A and B. The signatories of this MOU are threefold: Fermilab as host laboratory, the US CMS collaborating institution, and the US CMS PM. By

means of the mechanism of the MOU, the US CMS Project Manager will establish reporting by each institution which is part of the US CMS collaboration.

In turn, the US CMS Project reports cost, labor, schedule, and performance data to the US CMS Fermilab PMG. The objective of the reporting and review activity is to provide for the collection and integration of essential technical, cost, schedule, and performance progress data into the reports and reviews needed for managing and monitoring the US CMS Project. The following paragraphs describe the status and technical reports that will be provided.

A. Status Reporting

Project reporting and review will be divided into external and internal categories.

Status Reports will be prepared on a periodic basis. These reports are designed to portray the technical, cost, and schedule status of the Project at that particular point in time. In general, the reports will contain the following: Project cost trends; schedule accomplishments; critical items; commitment status; status of major procurements; budget versus cost projections; management assessments; variance analysis results and planned corrective action. The US CMS Project Manager will report at level 3 of the WBS. Reporting will be to the US CMS Fermilab PMG as the change control board and the group charged by DOE and NSF with management oversight. In addition the PM will report directly to DOE and NSF in the context of the annual budget request and also in the context of the annual allocation recommendation to each US CMS institution.

B. Design Reports

Design reports will be prepared and updated at the completion of a major system or component. The major phases are the Conceptual Design, Title I design, Title II Design, and as-built. The design reports will be prepared by the responsible level 2 manager and approved by the US CMS Project Manager. Technical reviews in addition to the Technical Design Report (TDR) required by CERN for subsystem approval will be organized by the PMG.

C. Meeting and Reviews

1. Internal US CMS Meetings

The US CMS PM and L2 managers will meet regularly with the US CMS Fermilab PMG to assess the current status of the Project, management issues, and proposed major charges.

2. Meetings with DOE and NSF

Monthly Meeting

A monthly meeting will be held between the PMG and the US CMS Project Manger and L2 managers to review the current status of Project work, to discuss outstanding issues, and to update previously identified action items. It is assumed that local representatives of both DOE and NSF will be members of the PMG.

Annual Review

Approximately every twelve months, a comprehensive review of the Project's cost, schedule, and technical status will be held by ER and NSF. Presentations by key US CMS Project personnel will address issues on an agenda agreed to in advance by ER, BAO, NSF, and the US CMS Project Manager. The first such review is scheduled for June 2-5, 1997.

Table IX-1: US CMS Institutions and Members

University of Alabama
L. Baksay*, B. Rouchouse, G. Zilizi

Boston University
E. Booth, R. Carey, S. Doulas, E. Hazen, O.C. Johnson, F. Krienen, J. Miller, D. Osborne, B.L. Roberts, J. Rohlf, A. Rosowsky, L. Sulak*, J. Sullivan, W. Worstell

Brookhaven National Laboratory
J. Kierstead, P. Levy, S. Stoll, C. Woody*

University of California, Davis
R. Breedon, Y. Fisyak, G. Grim, B. Holbrook, W. Ko*, R. Lander, S. Mani, D. Pellett, J. Rowe, J. Smith

University of California, Los Angeles
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* Institutional Representative

† Joint Appointment with Fermilab

Appendix A.

Memorandum of Understanding
between

<Institution>

and

US CMS Collaboration
Project Management
at Fermilab

<date signed>

1. Introduction

This Memorandum of Understanding describes the collaboration by members of <Institution> in the Compact Muon Solenoid (CMS) Project in the United States. The purpose of this collaboration is the design, fabrication, operation and scientific exploitation of the CMS Detector. The detector is described in the CMS Technical Proposal, December 15, 1994, the Technical Design Reports, and subsequent technical documents elaborating that design. The contribution of the US CMS Collaboration to the CMS Detector Project was first described in the US CMS Letter of Intent, September 15, 1995, in the US CMS Project Management Plan draft, April, 1997, and [other documents to be referenced here].

It is understood that successful collaboration in construction and operation of the CMS detector rests on implementation of a clear management plan for CMS. In the US, the US CMS Project Management Plan, <date2> (plus amendments as needed) is the basis for meeting this requirement and is accepted as part of this memorandum. The US CMS project management infrastructure (US CMS Project Office) resides at Fermilab, and the responsibility for US CMS project management resides in the US CMS PM/Spokesperson, acting with the advice and consent of the US CMS Management Board, and reporting to the US CMS Fermilab Project Management Group and to DOE and NSF.

The role of Fermilab as host institution, seat of the US CMS project office, and convener of the Project Management Group (PMG) is separate and distinct from Fermilab as a US CMS collaborating institution. The organization, leadership, operating procedures and present membership of the US CMS Collaboration are described in the US CMS Project Management Plan. The Plan will be updated as necessary and will constitute the basis for managing the US CMS Project.

This Memorandum of Understanding describes the anticipated long-term contributions of <Institution> to the design, construction and operation of the CMS Detector. It is understood that the anticipated contributions of <Institution> may later be modified or that additional responsibilities may be added to those described here.

An annual Statement of Work will detail the contributions of <Institution> as the detector construction proceeds and will contain the specific activities, deliverables and funding required. The normal period of performance will be the U.S. fiscal year (October 1-September 30).

This Memorandum of Understanding is made between <Institution> and US CMS Project Manager. It does not constitute a legal contractual obligation on the part of either of the parties. It reflects an arrangement that is currently satisfactory to the parties involved. The parties agree to negotiate amendments to this memorandum as required to meet the evolving requirements of the CMS research and development and detector construction program.

2. Personnel

2.1. List of Scientific Personnel

Participating scientists committed to CMS over the full project period are expected to be:

Name	CMS Fraction	Other Research Commitments/Comments

*Time devoted to CMS over and above the indicated CMS research fraction is considered to be <Institution> service effort in support of CMS.

2.2. Collaboration Board Representative

<Name> is the present representative of <Institution> on the US CMS Collaboration Board.

2.3. List of Technical Personnel

Participating technical staff members foreseen to participate over the full project period are:

Engineers

Designers

Technical Specialists

Programmers

Others

2.4. Other Key Personnel

The Environment, Safety and Health officer for <Institution> responsible for compliance with applicable ES&H policies associated with CMS participation by this institution is currently <name> of <Institution>. The Quality Assurance officer for <Institution> responsible for QA compliance of tasks performed by this institution is currently <name> of <Institution>.

3. Design, Fabrication and Installation Responsibilities

3.1. Design and Fabrication Responsibilities - Construction Period

3.1.1 *Description of Items Provided:*

WBS (L7)	Description

3.1.2 *Deliverables*

WBS (L7)	Deliverable

3.1.3 *Transportation*

Unless specifically indicated otherwise here, items produced by <Institution> for use in the CMS detector or subsystems shall be transported by the providing institution to the agreed upon point of delivery. <Institution> shall be responsible for safe transport of all items to these delivery points.

3.1.4 *Installation and Commissioning*

<Institution> will participate in the installation and commissioning of their contributed items as listed:

<Item 1>
<Item 2>...

3.2. Coordination and Reporting

The US CMS L2 manager for the <subsystem> subsystem is <name1>. The institution contact person for <subsystem> activities at <Institution> is <name2>. The task managers for <subsystem> activities carried out at <Institution> are as follows:

[Repeat as necessary for other subsystems in which <Institution> is participating.]

The progress of the design, fabrication, and testing of these components will be reported by the above-named task managers on a quarterly basis, by WBS element to L7 in detail, to the US CMS L2 Manager, who in turn will report subsystem

progress to the US CMS PM/Spokesperson. All status reports will be assembled and made public to the US CMS collaboration.

Technical reporting to CMS project management will be coordinated by the US CMS Subsystem Coordinator. Financial reporting to CMS will be made by the US CMS PM.

3.3. Collaboration with Other Groups and Institutions

Design, construction and installation related to the <subsystem> subsystem will be carried out in close communication and collaboration with other groups working on this and related subsystems.

WBS / Task (L7)	Collab. Group	Responsibility with <Institution>

[Repeat as necessary for other subsystems in which <Institution> is participating.]

4. Contribution of Effort, Services and Facilities

4.1. Effort

Subject to adequate funding by DOE or NSF, <Institution> will provide support for the scientific and technical personnel as indicated in section 2.

4.2. Services

The services of the <Institution> Purchasing, Expediting, and Receiving Departments and the Administrative Staff will be available to the CMS project to the degree required to carry out the fabrication responsibilities of <Institution>.

4.3. Facilities and Equipment

The following <Institution> facilities and equipment will be made available to the CMS project to the degree necessary to carry out the design and fabrication responsibilities of the group:

4.4. Operating Costs

<Institution>, subject to adequate funding from DOE or NSF, will support the normal research operating expenses (such as physicists' salaries, travel expenses, miscellaneous supplies, administrative support, etc.) of the <Institution> group

working on the CMS project. These normal operating expenses are not considered as part of the CMS detector cost estimate.

5. Expected Fermilab (as host institution) Effort, Services and Facilities

Subject to agreement, to be negotiated annually with the Fermilab Director, <Institution> expects the following Fermilab resources to be available in support of <Institution's> design, fabrication, and installation responsibilities:

5.1. Administrative and Technical Personnel

Participating Fermilab staff members foreseen to be available to the project are:

Administrative Staff

Engineers

Designers

Technical Specialists

Programmers

Others

Administrative and technical staff salary support may be paid by the US CMS Project, or may be provided by Fermilab as project host. The salary support of Fermilab staff contributing to <Institution's> responsibilities must be negotiated annually with the Fermilab Director. Support provided by Fermilab will be tracked and reported to the Fermilab Director.

5.2. Services

The services of the Fermilab Purchasing, Expediting, and Receiving Departments are expected to be available to <Institution> for the procurement of the following items:

<Item 1>
<Item 2>...

5.3. Facilities and Equipment

<Institution> expects that the following Fermilab facilities, equipment, and laboratory space will be available during the course of the project:

6. Costs and Funding

6.1. Tasks and Costs

<Institution> will carry out the following list of detector design, procurement, fabrication and installation tasks:

WBS (L7)	Item	Cost. Est. (K $)
	Total:	

Note: These costs do not include funds to be spent for procurement of <item>.

The US CMS Project Office at Fermilab will procure the following items:

WBS (l7)	Item	Cost. Est. (K $)
	Total:	

6.2. Expected Sources of Funding

Total project funds required from DOE or NSF is approximately <$x,xxxK>.

7. Administration

7.l. Method of Funding Transfers and Purchasing

The expenditures by <Institution> are to be covered by funds provided by DOE or NSF, upon the allocation decision of the US CMS PM/Spokesperson with the advice and consent of the US CMS Management Board and the concurrence of the US CMS Fermilab PMG. Purchases may be made in any of several ways:

a) Purchase Orders written by <Institution> against funds provided directly to <Institution> by DOE or NSF.

b) Purchase Orders written by <Institution> against a subcontract to <Institution> from the US CMS Project Office at Fermilab.

c) Purchase Orders written by the US CMS Project Office at Fermilab to <Institution> to cover specific equipment items agreed upon in this document.

d) Purchase Orders written by the US CMS Project Office at Fermilab to specific vendors, requesting the material to be delivered to <Institution>.

e) Purchase Orders written by the US CMS Project Office at Fermilab to cover fabrication work described in this document while specifying technical direction of the work by <Institution>.

Funds to cover work described in this document may be provided directly to <Institution> by DOE or NSF, or by subcontract from the US CMS Project Office at Fermilab. <Institution> may also choose to use Fermilab purchasing services as in c), d) and e) above. The choice of funding method shall be at the option of <Institution>, provided the arrangement is satisfactory to the US CMS PM.

Expenditures at <Institution> covered by purchase orders written by the US CMS Project Office at Fermilab to <Institution> will be reimbursed on a quarterly basis. Reimbursement will be based upon an invoice of actual costs incurred and submitted to the US CMS Project Office at Fermilab by <Institution>.

7.2. Procurement Authorization

Item purchases exceeding the delegated limit (currently <$xxK>) must be authorized by the US CMS L2 manager. Major procurements (currently <$xxK>) must in addition have the written authorization of the US CMS pm/Spokesperson. Items purchased as CMS Common Project items must be explicitly authorized by the US CMS PM/Spokesperson and approved by the CMS Finance Board Chair, regardless of the cost.

7.3. Reporting to US CMS Project Management

<Institution> will report all CMS related expenditures and labor charges together with associated technical progress in each item of work by Work Breakdown Structure (WBS) category (Level 7) on a quarterly basis through the appropriate US L2 Manager(s) to the US CMS PM/Spokesperson. Cost reporting will apply to US CMS Project funds related to detector fabrication. Other, non-DOE and non-NSF costs will be reported in a manner that is agreed to by the L2 Manager(s), the US PM/Spokesperson and <Institution>.

Technical progress will be reported by WBS element L7 to the L2 Manager and the PM/Spokesperson on a quarterly basis and will cover all activities covered in this Memorandum of Understanding regardless of the specific nature of the funding support. All status reports will be assembled and made public to the US CMS collaboration.

7.4. Overhead Charges

[The terms of this subsection remain to be negotiated...]

7.5. Component Ownership

All equipment items bought or fabricated using DOE or NSF funds will be properly marked as the property of DOE or NSF. Any other equipment furnished by <Institution> as part of the detector will remain <Institution> property. In either case, the equipment will remain part of the CMS detector until it is dismantled or the detector element in question is replaced.

8. General Considerations

8.1. Safety and Engineering Practices

The experimenters from <Institution> agree to familiarize themselves with DOE and NSF safety policies and to adhere to them. All detector components must be designed, fabricated, installed and operated in conformity with DOE, NSF and CERN safety policies and practices as well as DOE, NSF and CERN engineering standards. All engineering, design, quality assurance, safety, and other activities shall be in compliance with ISO standards. All major components will undergo appropriate design, safety, and engineering reviews.

8.2. Operations

<Institution> agrees to maintain, to the best of their ability, equipment provided for the CMS detector as long as <Institution> is a member of the CMS collaboration.

9. Schedules and Milestones

<Institution> will make every effort to carry out their institutional responsibilities consistent with the schedule for the fabrication of the CMS detector. These schedules may have to be changed as the project progresses. Changes that affect <Institution> will be noted in Amendments to this Memorandum.

9.1. Design, Fabrication and Installation Milestones

The key milestones relevant to <Institution> are listed here:

Key Milestones (L2 Schedule)	Baseline Date	Current Date

10. Makers and Concurrence

The following persons concur in the terms of this Memorandum of Understanding. These terms will be updated as appropriate in Amendments to this Memorandum.

Makers of this Memorandum:

<Name> date US CMS PM/Spokesperson	Administrative Officer date <title> <Institution>
<Name> date US L2 Manager <Subsystem> Subsystem	Institution Representative date <Name> <Institution>

Concurrence:

<Name> date Director Fermilab	<Name> date CMS Technical Representative

Appendix B.

Statement of Work

by

<Institution>

for Fiscal Year FY <n>

<date signed>

1. Introduction

This Statement of Work (SOW) is made to provide details of the work agreed to between the parties making the Memorandum of Understanding covering the specific period of performance from October 1, <start year> through September 30, <end year>. It is subject to all the points of agreement and conditions in the current version of the parent Memorandum and the current version of the US CMS Project Management Plan.

2. Personnel

2.1. List of Scientific Personnel

Participating scientists with anticipated fraction of their research time committed to CMS during this period of performance are:

Name	CMS Fraction	Other Research Commitments / Comments

*Time devoted to CMS over and above the indicated CMS research fraction is considered to be <Institution> service effort in support of CMS.

2.2. Collaboration Board Representative

<Name> is the present representative of <Institution> on the US CMS Collaboration Board.

2.3. List of Technical Personnel

Participating technical personnel with the anticipated fraction of their time committed to CMS during this period of performance and their source(s) of support are:

Engineers

Name	CMS Fraction	Source of Support

Designers

Name	CMS Fraction	Source of Support

Technical Specialists

Name	CMS Fraction	Source of Support

Programmers

Name	CMS Fraction	Source of Support

Others

Name	CMS Fraction	Source of Support

2.4. Other Key Personnel

The Environment, Safety and Health officer for <Institution> currently responsible for compliance with applicable ES&H policies associated with CMS participation by this institution is <ES&H Name> of <Institution>. The Quality Assurance officer for <Institution> currently responsible for QA compliance of tasks performed by this institution is <QA Name> of <Institution>.

3. Design, Fabrication and Installation Responsibilities

3.1. Design and Fabrication Responsibilities for this Period of Performance

3.1.1. *Description of items (or partial completion of items) provided in this period (Statements of Work):*

WBS (L7)	Statement of Work text

3.1.2 *Deliverables:*

WBS (L7)	Deliverable

3.2. Coordination and Reporting

The US CMS L2 Manager for the <subsystem> subsystem is <name1>. The institution contact person for <subsystem> activities at <Institution> is <name2>. The task managers for <subsystem> activities carried out at <Institution> are as follows:

[Repeat as necessary for other subsystems in which <Institution> is participating.]

3.3. Collaboration with Other Groups and Institutions

Design, construction and installation related to the <subsystem> subsystem will be carried out in close communication and collaboration with other groups working on this and related subsystems.

WBS / Task	Collab. Group	Responsibility with <Institution>

[Repeat as necessary for other subsystems in which <Institution> is participating.]

4. Contribution of Effort, Services and Equipment

4.1. Effort

Subject to adequate funding by DOE or NSF, <Institution> will provide support for the scientific and technical personnel as indicated in section 2 during this period of performance.

5. Fermilab (as host institution) Effort, Services and Facilities

Tracking of Fermilab CMS support, whether provided by Fermilab or paid by the US CMS Project, will be done using appropriate effort reporting codes. The costs incurred will be reported to the Fermilab Director.

5.1. Administrative and Technical Personnel

Contributing Fermilab personnel with the anticipated fraction of their time committed to CMS during this period of performance and their source(s) of support are:

Administrative Staff

Name	CMS Fraction	Source of Support

Engineers

Name	CMS Fraction	Source of Support

Designers

Name	CMS Fraction	Source of Support

Technical Specialists

Name	CMS Fraction	Source of Support

Programmers

Name	CMS Fraction	Source of Support

Others

Name	CMS Fraction	Source of Support

6. Costs and Funding

6.1. Tasks and Costs

<Institution> will carry out the following list of detector design, fabrication and installation tasks during this period of performance:

WBS (L7)	Task	Cost. Est. (K $)	DOE Funds (NSF) (K $)
	Total:		

The cost of the detector elements covered under the US CMS WBS are taken in detail from the current US CMS Cost Estimate (<Date>). DOE (NSF) Funds indicate the project funds to be provided in this period of performance.

6.2. Expected Sources of Funding

WBS (L7)	Task	DOE Funds (NSF) (K $)
	Total DOE (NSF) Funds:	

An amount of $<x,xxx>K will be provided for the period <Date1> - <Date2> to cover work for the first six months. The remaining funds needed to complete the tasks described in 6.1 will be provided subject to availability of funding and performance during the first half year.

7. Administration (no amendments are included in this section)

8. General Considerations (no amendments are included in this section)

9. Schedules and Milestones

<Institution> will make every effort to carry out their institutional responsibilities consistent with the overall CMS schedule. In this amendment are listed the program milestones for this period of performance.

9.1. Design, Fabrication and Installation Milestones

The program milestones for this period of performance relevant to <Institution> are listed here:

Program Milestones	Baseline Date	Current Date

10. Makers and Concurrence

The following persons concur in the terms of this Amendment These terms will be updated as appropriate in later Amendments to this Memorandum.

Makers of this Memorandum:

<Name> date US CMS PM/Spokesperson	Institution Representative date <title> <Institution>
US L2 Manager <Name> date <Subsystem> Subsystem	

Concurrence:

<Name> date Director Fermilab	<Name> date CMS Technical Representative